Appendices

Appendix A. Implementing Agreement

IMPLEMENTING AGREEMENT

by and between

CITY OF PORTLAND, OREGON, WATER BUREAU

and

NATIONAL MARINE FISHERIES SERVICE

TO ESTABLISH A MITIGATION PROGRAM FOR ENDANGERED AND THREATENED SPECIES AT THE CITY OF PORTLAND'S BULL RUN WATER SUPPLY FACILITIES, MULTNOMAH AND CLACKAMAS COUNTIES, OREGON

This Implementing Agreement ("Agreement"), made and entered into as of the _____ day of ____________, 2008, by and among the City of Portland, Oregon, Water Bureau (hereinafter Portland) and the National Marine Fisheries Service (NMFS) (the Service), hereinafter collectively called the "Parties," defines the Parties' roles and responsibilities and provides a common understanding of action that will be undertaken to minimize and mitigate the effects on the subject listed and unlisted species and their habitats of the City of Portland's water supply operations in the Bull Run Watershed and the Sandy River Basin.

1.0 RECITALS AND PURPOSES

1.1 **RECITALS:** This Agreement is entered into with regard to the following facts:

WHEREAS, The Bull Run Watershed, including those portions that are owned by the City, has been determined to provide, or potentially provide, habitat for a variety of species of fish and wildlife that pursuant to the Endangered Species Act, are listed as threatened, or are candidates for such listing, or are otherwise considered species of concern. These species are identified in Table 3.1 of the Habitat Conservation Plan that is the subject of this agreement, attached hereto as Exhibit 1; and,

WHEREAS, Portland, with technical assistance from the Sandy River Basin Partners (which includes the Service, the U.S. Fish and Wildlife Service, the United States Forest Service, and the Oregon Department of Fish and Wildlife) , has developed a series of measures, described in the Habitat Conservation Plan, to minimize and mitigate the effects of the covered activities associated with the Bull Run water supply operations upon the subject listed and unlisted species and their associated habitats.

1.2 PURPOSES: The purposes of this Agreement are:

1.2.1 To ensure implementation of each of the terms of the HCP;

1.2.2 To describe remedies and recourse should any Party fail to perform its obligations, responsibilities, and tasks as set forth in this Agreement; and,

1.2.3 To provide assurances to Portland that as long as the terms of the HCP and the Permit issued pursuant to the HCP and this Agreement are fully and faithfully performed, no additional mitigation will be required except as provided for in this Agreement or required by law.

2.0 DEFINITIONS: The following terms as used in this Agreement shall have the meanings set forth below:

2.1 "Permit" or ITP shall mean the incidental take permit issued by the Service to Portland pursuant to Section 10(a)(1)(B) of the Endangered Species Act (ESA).

2.2 "Conservation Plan" or "HCP" shall mean the Habitat Conservation Plan prepared for the Bull Run Watershed water supply operations.

2.3 "Covered lands" shall mean those lands listed as "covered lands" in the HCP, that is, including lands and facilities associated with and/or potentially affected by covered activities located within the hydrologic boundary of the Sandy River Basin in Clackamas and Multnomah Counties, Oregon, as depicted in Figure 2-1 of the HCP.

2.4 "Permittee" shall mean the City of Portland Water Bureau, hereinafter referred to either as Portland or the Permittee.

2.5 "Covered species" shall mean species adequately covered in the HCP and identified in Table 3.1 of the HCP and Exhibit 1 of this Agreement.

2.6 "Covered activities" shall mean those activities described as covered activities in the HCP, that is, City activities associated with covered lands and facilities to the extent they affect covered species, including operation, maintenance and repair of the water system; implementation of habitat conservation, research, and monitoring; and incidental land management related to the water system and HCP implementation.

2.7 "Covered facilities" shall mean those facilities listed as "covered facilities" in the HCP, that is, facilities owned, operated, and/or used by the City as part of the Bull Run water supply system within the hydrologic boundary of the Sandy River Basin to the extent these facilities are affected by the covered activities.

2.8 “Changed circumstances” means only those circumstances described in Chapter 10 of the HCP which fall into three general categories: climate change, change in status of habitat, and change in status of a species.

2.9 “Unforeseen circumstances” means any significant, unanticipated adverse change in the status of species addressed under the HCP or in their habitats; or any significant unanticipated adverse change in impacts of the project or in other factors upon which the HCP is based. The term “unforeseen circumstances” as defined in this Agreement is intended to have the same meaning as in the Service’s No Surprises policy.

2.10 “Force Majeure” means events that are beyond the reasonable control of, and that did not occur through the fault or negligence of, Portland or any entity controlled by Portland, including its contractors and subcontractors to the extent they are carrying out authorized activities, that wholly or partially prevent the City from performing obligations under the HCP and this Agreement. Force Majeure events include but are not limited to acts of God, sudden actions of the elements, or actions of local, state, or federal agencies or courts. Force Majeure does not include circumstances described as “changed circumstances” in the HCP.

2.11 Terms defined in Endangered Species Act. Terms used in this agreement that are specifically defined in the ESA, in regulations adopted by the Service under the ESA, or the “no surprises policy,” shall have the same meaning as in the ESA, those implementing regulations, and that policy, unless this agreement expressly provides otherwise.

3.0 INCORPORATION OF HCP

The HCP and each of its provisions are intended to be, and by this reference are, incorporated herein. In the event of any direct contradiction between the terms of this Agreement and the HCP, the terms of this Agreement shall control. In all other cases, the terms of this Agreement and the terms of the HCP shall be interpreted to be supplementary to each other.

4.0 LEGAL REQUIREMENTS

In order to fulfill the requirements that will allow the Service to issue the Permit, the HCP sets forth measures that are intended to ensure that any take associated with covered activities on covered lands or at covered facilities will be incidental; that the impacts of the take will, to the maximum extent practicable, be minimized and mitigated; that procedures to deal with changed circumstances will be provided; that adequate funding for the HCP will be provided; and that the take will not appreciably reduce the likelihood of the survival and recovery of the covered species in the wild. It also includes measures that have been suggested by the Service as being necessary or appropriate for purposes of the HCP.

5.0 TERM

This Agreement shall become effective on the date that the Service issues the Permit requested in the HCP and shall remain in full force and effect for a period of 50 years or until termination of the Permit, whichever occurs sooner.

6.0 FUNDING

Portland will provide such funds as may be necessary to carry out its obligations under the HCP. Portland should notify the Service if the Permittee's funding resources have materially changed, including a discussion of the nature of the change, from the information provided in Chapter 11 of the HCP.

7.0 RESPONSIBILITIES OF THE PARTIES IN MITIGATION PROGRAM IMPLEMENTATION AND MONITORING RESPONSIBILITIES OF THE PERMITTEE

7.1 PORTLAND'S RESPONSIBILITIES

7.1.1 The HCP will be properly functioning if the terms of the Agreement have been or are being fully implemented.

7.1.2 Portland shall undertake all activities set forth in the HCP in order to meet the terms of the HCP and comply with the Permit, including adaptive management procedures described in Chapter 9 of the HCP.

7.1.3 Portland shall submit an annual report, or a report at a frequency mutually agreeable to the parties, describing its activities during the relevant year, including implementation of HCP measures, documentation of progress toward meeting the HCP's measurable habitat objectives, cumulative effects and analysis of whether the terms of the HCP were met for the reporting period. The report shall rely upon and reference all reasonably available data regarding HCP-related activities and Portland shall make the underlying data available to the Service upon request. Anticipated components include planning and implementation of measures, expenditures, compliance and effectiveness monitoring, fish population research as required by the HCP, and any plans or actions related to changed circumstances and/or adaptive management. The report shall also include the following certification from a responsible City official who supervised or directed the preparation of the report:

> Under penalty of law, I certify that, to the best of my knowledge, after appropriate inquiries of all relevant persons involved in the preparation of this report, the information submitted is true, accurate, and complete.

7.2 RESPONSIBILITIES OF THE SERVICE

7.2.1 The Service shall cooperate and provide, to the extent funding is available, technical assistance to implement the Framework for Adaptive Response as detailed in Section 9.4.3 and Table 9-4 of the HCP. Nothing in this Agreement shall require the Service to act in a manner contrary to the requirements of the Anti-Deficiency Act.

7.2.2 After issuance of the Permit, the Service shall monitor the implementation thereof, including each of the terms of this Agreement and the HCP in order to ensure compliance with the Permit, the HCP and this Agreement.

8.0 DISPUTE RESOLUTION

Any Party to this agreement claiming a dispute shall notify the other Party of the dispute within 20 days of such Party's actual knowledge of the act, event, or omission that gives rise to the dispute. The Parties shall convene at least one meeting within 20 days after such notice, to attempt to resolve the dispute. If the dispute is not resolved within 15 days of the meeting, the Parties may agree to attempt to resolve the dispute using a neutral mediator unanimously selected by the Parties. The mediator shall mediate the dispute in accordance with the instructions and schedule provided to it by the Parties. Any of these time periods may be reasonably extended or shortened by agreement of the Parties, or as necessary to conform to the procedure of an agency or court with jurisdiction over the dispute. Unless otherwise agreed among the Parties, each Party shall bear its costs for its own participation in the dispute resolution. In all cases, the Parties shall proceed expeditiously to allow either Party to meet any regulatory, statutory or judicial deadlines regarding the subject matter of the dispute.

9.0 REMEDIES AND ENFORCEMENT

9.1 REMEDIES IN GENERAL

Except as set forth below, each Party shall have all remedies otherwise available to enforce the terms of this Agreement, the Permit, and the HCP, and to seek remedies for any breach hereof, subject to the following:

9.1.1 NO MONETARY DAMAGES: No Party shall be liable in damages to the any other Party or other person for any breach of this Agreement, any performance or failure to perform a mandatory or discretionary obligation imposed by this Agreement or any other cause of action arising from this Agreement. Notwithstanding the foregoing:

9.1.1.1 <u>Retain Liability:</u> All Parties shall retain whatever liability they would possess for their present and future acts or failure to act without existence of this Agreement.

9.1.1.2 Land Owner Liability: All Parties shall retain whatever liability they possess as an owner of interests in land.

9.1.1.3 Responsibility of the United States: Nothing contained in this Agreement is intended to limit the authority of the United States government to seek civil or criminal penalties or otherwise fulfill its enforcement responsibilities under the ESA.

9.1.2 INJUNCTIVE AND TEMPORARY RELIEF

The Parties acknowledge that the covered species are unique and that their loss as species would result in irreparable damage to the environment and that therefore injunctive and temporary relief may be appropriate to ensure compliance with the terms of this Agreement.

9.2 PERMIT SUSPENSION OR REVOCATION

Except as otherwise provided for under the terms of the Agreement, the Permit shall be suspended or revoked only in conformance with the provisions of 50 CFR 13.27 through 13.29 (1994), as the same exists as of the date hereof.

9.3 LIMITATIONS AND EXTENT OF ENFORCEABILITY

9.3.1 NO SURPRISES POLICY

Subject to the availability of appropriated funds as provided in Paragraph 14.6 hereof, and except as otherwise required by law, no further mitigation for the effects of the covered activities on covered lands or at covered facilities upon the covered species may be required from a Permittee who has otherwise abided by the terms of the HCP, except in the event of unforeseen circumstances; provided that any such additional mitigation may not require additional land or water use restrictions or financial compensation from the Permittee without its written consent.

9.3.2 PRIVATE PROPERTY RIGHTS AND LEGAL AUTHORITIES UNAFFECTED

Except as otherwise specifically provided herein, nothing in this Agreement shall be deemed to restrict the rights of Portland to the use or development of those lands, or interests in lands, constituting covered lands, to the use or development of covered facilities, or to the use or development of water rights or claims to water rights held by the City; provided, that nothing in this Agreement shall absolve Portland from such other limitations as may apply to such lands, interests in lands, facilities, water rights, or claims to water rights under other laws of the United States and the State of Oregon. Nothing in this agreement shall be construed to give the Service the authority to impose or seek to impose measures additional to those specified in the HCP or this agreement that would degrade drinking water quality, trigger a need for additional water treatment, or require commitment of additional water to purposes other than municipal water supply.

9.3.3 FORCE MAJEURE

9.3.3.1 Force Majeure procedures. In the event that Portland is wholly or partially prevented from performing obligations under this agreement because of a Force Majeure event, the City will be excused from whatever performance is affected by such Force Majeure event to the extent so affected, and such failure to perform will not be considered a material breach provided that nothing in this section will be deemed to authorize the City to violate the ESA or render the goals of the HCP unobtainable, and provided further that:

(a) The suspension of performance is of no greater scope and no longer duration than is reasonably required by the Force Majeure;

(b) The City notifies the Service orally within a reasonable time (normally not to exceed 72 hours) after becoming aware of any event that the City contends constitutes a Force Majeure, and in writing within seven (7) calendar days after the event. Such notice will: identify the event causing the delay or anticipated delay; estimate the anticipated length of delay; state the measures taken or to be taken to minimize the delay; and estimate the timetable for implementation of the measures;

(c) The City uses its best efforts to avoid and mitigate the effects of any delay upon its ability to perform. A Force Majeure event may require use of the adaptive management provisions of this agreement and the HCP in remedying the effects of the Force Majeure event; and

(d) When the City is able to resume performance of its obligations, it provides the Service written notice to that effect.

9.3.3.2 Termination through Force Majeure. Any party may terminate the HCP if a Force Majeure event renders the goals of the HCP unobtainable.

10.0 AMENDMENTS

Except as otherwise set forth herein, this Agreement may be amended consistent with the ESA and with the written consent of each of the Parties hereto.

11.0 MINOR MODIFICATIONS

11.1 The HCP, including its appendices, is a very lengthy and complex document, and the parties recognize that various minor and non-controversial corrections and adjustments may from time to time be required. Any party may propose minor modifications to the HCP or this agreement by providing written notice to all other parties. Such notice shall include a statement of the reason for the proposed modification and an analysis of its environmental effects, including its effects on operations under the HCP and on covered species. The parties will use best efforts to respond to proposed modifications within 60 days of receipt of such notice. Proposed modifications will become effective upon all other parties' written approval. If, for any reason, a receiving party objects to a proposed modification, it must be processed as an amendment of the permit in accordance with section 13 of this agreement. The Service will not propose or approve minor modifications to the HCP or this agreement if the Service determines that such modifications would result in operations under the HCP that are significantly different from those analyzed in connection with the original HCP, or would result in adverse effects on the environment that are new or significantly different from those analyzed in connection with the original HCP, or additional take not analyzed in connection with the original HCP.

11.2 Minor modifications to the HCP and IA processed pursuant to this subsection may include but are not limited to the following:

11.2.1 Corrections of typographic, grammatical, and similar editing errors that do not change the intended meaning;

11.2.2 Corrections of any maps or exhibits to correct errors in mapping or to reflect previously approved changes in the permit or HCP;

11.2.3 Minor changes to survey, monitoring or reporting protocols;

11.2.4 Minor corrections and adjustments to the HCP, including changes in implementation schedules of up to two years.

11.3 Decisions on specific design details for facilities, studies, projects, or adaptive management strategies identified in the HCP are not modifications or amendments and may proceed without processing as amendments or modifications.

12.0 RELATIONSHIP TO FERC LICENSE, PROJECT NO. 2821

The City operates hydroelectric generators at its Bull Run Dams No. 1 and 2 under license from the Federal Energy Regulatory Commission. Generation of electricity at the dams is subordinate to water supply operations. The City's hydroelectric license is effective until March 1, 2029. If the City wishes to continue generation of electricity at the project after that date, it will seek a new license before license expiration. The parties agree that the HCP will be used as part of the required Exhibit E. Unless one of the changed circumstances described in the HCP has arisen, the Service shall endorse the HCP as the appropriate fish and wildlife terms and conditions for covered species for a new license with a term coincident with the remaining term of the HCP. Should FERC impose, as part of a new license, conditions that are inconsistent with or make impossible the implementation of any provision of the HCP, the City may decline to accept the new license and cease production of electricity at the projects or the City may ask the Service to enter into good-faith discussions. The purpose of those discussions will be to review the HCP, seeking ways to make the license and HCP consistent and to establish mechanisms to allow implementation of or change to HCP measures affected by license conditions. If the parties are not able to reach an agreement and the City accepts a FERC license that makes impossible the implementation of any provision of the HCP, the new license may be treated by any party as a Force Majeure event under the terms of this Implementing Agreement.

13.0 NEW LISTINGS

The ITP for federally listed species will be issued contemporaneously with the signing of this Agreement. In the future during the term of the Agreement, should any other covered species become listed, the Service shall add to the ITP, within sixty (60) days of receipt by the appropriate Service of a written request by the City, each such species at the level of take requested by the City and supported by the HCP without requiring additional mitigation, unless, within the specified sixty-day period, the Service demonstrates that unforeseen circumstances exist. If such unforeseen circumstances are found to exist, the Service may request or provide additional mitigation as provided in this agreement.

14.0 MISCELLANEOUS PROVISIONS

14.1 NO PARTNERSHIP

Except as otherwise expressly set forth herein, neither this Agreement nor the HCP shall make or be deemed to make any Party to this Agreement the agent for or the partner of any other Party.

14.2 SUCCESSORS AND ASSIGNS

This Agreement and each of its covenants and conditions shall be binding on and shall inure to the benefit of the Parties hereto and their respective successors and assigns.

14.3 NOTICE

Any notice permitted or required by this Agreement shall be delivered personally to the persons set forth below or shall be deemed given five (5) days after deposit in the United States mail, certified and postage prepaid, return receipt requested and addressed as follows or at such other address as any Party may from time to time specify to the other Parties in writing:

Assistant Regional Director
National Marine Fisheries Service
1201 NE Lloyd Blvd, Suite 1100
Portland, OR 97232

Administrator
Portland Water Bureau
1120 SW 5th Avenue
Portland, OR 97204

14.4 ENTIRE AGREEMENT

This Agreement, together with the HCP and the Permit, constitutes the entire Agreement between the Parties. It supersedes any and all other Agreements, either oral or in writing among the Parties with respect to the subject matter hereof and contains all of the covenants and Agreements among them with respect to said matters, and each Party acknowledges that no representation, inducement, promise or Agreement, oral or otherwise, has been made by any other Party or anyone acting on behalf of any other Party that is not embodied herein.

14.5 ELECTED OFFICIALS NOT TO BENEFIT

No member of or delegate to Congress shall be entitled to any share or part of this Agreement, or to any benefit that may arise from it.

14.6 AVAILABILITY OF FUNDS

Implementation of this Agreement and the HCP by the Service is subject to the requirements of the Anti-Deficiency Act and the availability of appropriated funds. Nothing in this Agreement will be construed by the parties to require the obligation, appropriation, or expenditure of any money from the U.S. treasury. The parties acknowledge that the Service will not be required under this Agreement to expend any Federal agency's appropriated funds unless and until an authorized official of that agency affirmatively acts to commit to such expenditures as evidenced in writing.

14.7 DUPLICATE ORIGINALS

This Agreement may be executed in any number of duplicate originals. A complete original of this Agreement shall be maintained in the official records of each of the Parties hereto.

14.8 THIRD PARTY BENEFICIARIES

Without limiting the applicability of the rights granted to the public pursuant to the provisions of 16 U.S.C. § 1540(g), this Agreement shall not create any right or interest in the public, or any member thereof, as a third party beneficiary hereof, nor shall it authorize anyone not a Party to this Agreement to maintain a suit for personal injuries or property damages pursuant to the provisions of this Agreement. The duties, obligations, and responsibilities of the Parties to this Agreement with respect to third parties shall remain as imposed under existing Federal or State law.

14.9 RELATIONSHIP TO THE ESA AND OTHER AUTHORITIES

The terms of this Agreement shall be governed by and construed in accordance with the ESA and other applicable laws. In particular, nothing in this Agreement is intended to limit the authority of the Service to seek penalties or otherwise fulfill its responsibilities under the ESA. Moreover, nothing in this Agreement is intended to limit or diminish the legal obligations and responsibilities of the Service as an agency of the Federal government.

14.10 REFERENCES TO REGULATIONS

Any reference in this Agreement, the HCP, or the Permit to any regulation or rule of the Service shall be deemed to be a reference to such regulation or rule in existence at the time an action is taken.

14.11 APPLICABLE LAWS

All activities undertaken pursuant to this Agreement, the HCP, or the Permit must be in compliance with all applicable State and Federal laws and regulations.

IN WITNESS WHEREOF, THE PARTIES HERETO have executed this Implementing Agreement to be in effect as of the date last signed below.

BY ____ Date _________

Bob Lohn
National Marine Fisheries Service
Seattle, Washington

BY ____ Date _________

Randy Leonard
Commissioner in Charge, Portland Water Bureau
Portland, Oregon

Appendix B. River Reach Lengths by Watershed

Table B-1 of this appendix defines the stream reach names in the Sandy River Basin, as used in the Habitat Conservation Plan (HCP) and the Sandy River Basin Characterization Report (Sandy River Basin Partners 2005). The reach lengths that appear in this appendix are from a geographic information systems (GIS) database and were first published in the Sandy River Basin (SRB) Characterization Report. The reach lengths from the SRB Characterization Report were used for general planning and discussion of the HCP measures. In some cases, the reach lengths in the SRB Characterization Report differ from the reach lengths used in Chapters 5 and 8 of this HCP. Where the difference occurs, the reach lengths in Chapters 5 and 8 are based on specific stream surveys.

The reach lengths in Chapters 5 and 8 were developed by the Sandy River Basin Agreement Technical Team (SRBTT). The SRBTT reviewed all existing stream survey reports for the Sandy River Basin and defined these reaches based on stretches of relatively homogeneous habitat conditions (USFS 1999). The reach breaks were established based on a variety of factors, such as transitions in geomorphic characteristics, stream gradient, channel form, condition of the riparian zone, locations of confluences with major tributaries, presence of artificial structures such as Marmot Dam, and other similar features.[1]

The reach lengths and river miles presented in this appendix are from a GIS database.

Table B-1. River Reach Lengths by Watershed

Reach	Reach length (miles)	River miles
Bull Run Watershed		
Blazed Alder 1	2.5	0.0–2.5
Bull Run Bear 1	0.3	0.0–0.3
Bull Run Camp 1	0.1	0.0–0.1
Bull Run Camp 2	0.5	0.1–0.6
Bull Run Cedar 1	8.1	0.0–8.1
Bull Run 1	1.7	0.0–1.7
Bull Run 2	1.7	1.7–3.4
Bull Run 3	0.8	3.4–4.2
Bull Run 4	2.3	4.2–6.5
Bull Run 5 (Dam 2 diversion pool)	0.0	6.5–6.5
Bull Run 6 (Reservoir 2)	4.6	6.5–11.1
Bull Run 6A (Reservoir 1)	3.7	11.1–14.8
Bull Run 7	1.7	14.8–16.5
Bull Run 8	0.8	16.5–17.3
Bull Run 9	3.2	17.3–20.5
Bull Run 10	0.8	20.5–21.2

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[1] Since the first Services Review Draft of the HCP was published in November 2006, the Marmot Dam has been decommissioned and removed (July 2007) and the Little Sandy Dam is slated to be decommissioned and removed in 2008.

Table B-1. River Reach Lengths by Watershed, continued

Reach	Reach length (miles)	River miles
Bull Run Watershed (continued)		
Cougar 1	0.2	0.0–0.2
Cougar 2	0.4	0.2–0.6
Deer 1	0.2	0.0–0.2
Deer 2	0.2	0.2–0.4
Falls Creek 1	1.1	0.0–1.1
Fir 1	0.5	0.0–0.5
Little Sandy 1	1.8	0.0–1.8
Little Sandy 2	5.9	1.8–7.7
N.F. Bull Run 1	0.2	0.0–0.2
N.F. Bull Run 2	0.6	0.2–0.8
S.F. Bull Run 1	0.5	0.0–0.5
S.F. Bull Run 2	2.2	0.5–2.7
Lower Sandy Watershed		
Beaver 1A	1.9	0.0–1.9
Beaver 1B	0.3	1.9–2.2
Beaver 1C	1.9	2.2–1.9
Beaver 1D	3.1	1.9–5.0
Big 1	4.0	0.0–4.0
Buck 1	0.4	0.0–0.4
Burlingame 1	0.5	0.0–0.5
Gordon 1A	1.6	0.0–1.6
Gordon 1B	2.4	1.6–4.0
Gordon 2A	3.2	0.0–3.2
Gordon 2B	0.2	3.2–3.4
Kelly 1	1.8	0.0–1.8
Sandy 1	5.4	0.0–5.4
Sandy 2	12.4	5.4–17.8
Smith 1	2.9	0.0–2.9
Trout 1A	0.5	0.0–0.5
Trout 2A	0.3	0.5–0.8
Trout 3A	0.5	0.8–1.3
Walker 1	0.1	0.0–0.1
Middle Sandy Watershed		
Alder 1	0.9	0.0–0.9
Alder 1A	1.1	0.9–2.0
Alder 2	0.7	2.0–2.7
Alder 3	2.8	2.7–5.5
Cedar 1	1.5	0.0–1.5
Cedar 2	3.4	1.5–4.9

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Table B-1. River Reach Lengths by Watershed, continued

Reach	Reach length (miles)	River miles
Middle Sandy Watershed (continued)		
Cedar 3	5.3	4.9–10.2
Cedar 4	4.5	10.2–14.7
Sandy 3	5.8	17.8–23.6
Sandy 4	4.2	23.6–27.8
Sandy 5	1.4	27.8–29.2
Marmot Dam	0.0	29.2–29.2
Sandy 6	1.8	29.2–31.0
Sandy 7	5.9	31.0–36.9
Wildcat 1	0.4	0.0–0.4
Wildcat 2	1.2	0.4–1.6
Wildcat 3	0.2	1.6–1.8
Upper Sandy Watershed		
Bear 1	1.3	0.0–1.3
Cast 1	1.0	0.0–1.0
Clear 1A	3.1	0.0–3.1
Clear 1B	1.2	3.1–4.3
Clear Fork 1A	0.3	0.0–0.3
Clear Fork 1B	0.3	0.3–0.5
Clear Fork 1C	1.5	0.5–2.0
Clear Fork 1D	2.8	2.0–4.8
Hackett 1	3.1	0.0–3.1
Horseshoe 1	1.4	0.0–1.4
Little Clear 1	0.8	0.0–0.8
Lost 1A	3.5	0.0–3.5
Lost 1B	1.0	3.5–4.5
Lost Tributary 1	1.3	0.0–1.3
Muddy Fork 1	2.5	0.0–2.5
Muddy Fork 2	1.0	2.5–3.5
N. Boulder 1	1.2	0.0–1.2
N. Boulder 2	1.2	1.2–2.4
Rushing Water 1	1.2	0.0–1.2
Sandy 8	5.6	36.9–42.6
Sandy 9	6.8	42.6–49.4
Sandy 10	3.1	49.4–52.5
Sandy 11	0.9	52.5–53.4
Sandy 12	0.8	53.4–54.2
Salmon River Watershed		
Boulder 0	0.3	0.0–0.3
Boulder 1	0.6	0.3–0.9

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Table B-1. River Reach Lengths by Watershed, continued

Reach	Reach length (miles)	River miles
Salmon Watershed (continued)		
Boulder 2	3.7	0.9–4.6
Cheeney 1	1.0	0.0–1.0
Cheeney 1A	2.0	1.0–3.0
Mack Hall 1	2.9	0.0–2.9
S. Fork Salmon 1	1.4	0.0–1.4
S. Fork Salmon 2	3.8	1.4–5.2
Salmon 1	0.9	0.0–0.9
Salmon 2	6.2	0.9–7.1
Salmon 3	6.2	7.1–13.3
Sixes Creek 2	1.6	0.0–2.3
Wee Burn 1	1.0	0.0–1.0
Zigzag Watershed		
Camp Creek 1A	0.4	0.0–0.4
Camp Creek 1B	3.6	0.4–4.0
Camp Creek 1C	1.3	4.0–5.3
Cool 1	0.5	0.0–0.5
Devils Canyon 1A	0.8	0.0–0.8
Henry 1	1.4	0.0–1.4
Lady 1	1.2	0.0–1.2
Little Zigzag 1	1.4	0.0–1.4
Still 1	1.0	0.0–1.0
Still 1A	2.2	1.0–3.2
Still 2	4.1	3.2–7.3
Still 3	2.1	7.3–9.4
Still 4	3.4	9.4–12.8
Still 5	1.6	12.8–14.4
Wind 1	0.3	0.0–0.3
Zigzag 1A	2.2	0.0–2.2
Zigzag 1B	5.1	2.2–7.3
Zigzag 1C	2.1	7.3–9.4

Source: Sandy River Basin Characterization Report 2005

Appendix C. Current and Historical Distribution of the Covered Species in the Sandy River Basin Watershed

The current and historical distribution of the four primary covered species, fall Chinook salmon, spring Chinook salmon, winter steelhead trout, and coho, are shown in the maps in Chapter 5. Table C-1 in this appendix describes the current and historical distribution by reach within each subwatershed in the Sandy River Basin.

The data for this distribution were collected through the combined efforts of several organizations that collaborated as the Sandy River Basin Agreement Technical Team (SRBTT). Representatives from eight organizations, including fish biologists and other scientists with field experience, participated in the data-gathering effort. These entities are listed below:

- U.S Bureau of Land Management
- City of Portland Water Bureau
- Clackamas County
- National Marine Fisheries Service
- Oregon Department of Environmental Quality
- Oregon Department of Fish and Wildlife
- U.S. Fish and Wildlife Service
- U.S. Forest Service

Between August and December of 2000, the SRBTT compiled all of the available data for streams in the Sandy River Basin, including stream surveys and reach habitat ratings. The data were cross-checked and verified against the SRBTT's observations and experience, then entered into the Ecosystem Diagnosis and Treatment (EDT) model to determine the current and historical distribution of the four species. The results of the modeling were used to create the maps that appear in Chapter 5.

The current and historical distributions of the covered species in the Sandy River Basin were used by the City to help describe the current condition of the species and to help select appropriate reaches that could be improved by the conservation measures. References in the HCP to the information in this appendix are found primarily in Chapters 5 and 8.

The information presented in this appendix is the EDT model results shown in tabular form, rather than in maps, to facilitate finding the distribution of each species in a particular reach. Under each species name, the cells and marks indicate whether the species is currently present (a solid bullet •); historically present (an open circle ∘); neither currently nor historically present (empty cell); or historically present but access has been blocked by a barrier (open circle in a cell that is shaded gray ∘).

Several areas of the Sandy River Basin are currently not accessible to anadromous salmonids. Fall Chinook no longer use the upper Sandy (above the Marmot Dam site), Zigzag, or Salmon watersheds. The SRBTT agreed that the representation of current fall Chinook salmon distribution in the EDT database should end at the Marmot Dam site, although the dam did not obstruct spring Chinook, coho, or winter steelhead.[1] The reason fall Chinook are restricted to below the Marmot Dam site is unknown. Anadromous fish do not currently use the upper Bull

[1] Marmot Dam was decommissioned and removed in July 2007.

Run River because the dams do not have fish passage facilities. Access to the upper Little Sandy River is currently blocked by Portland General Electric's (PGE's) dam but that structure is scheduled to be removed in 2008. Fish access is partially blocked in several reaches of Beaver and Kelly creeks in the lower Sandy River Basin because of culverts and a pond on the Mt. Hood Community College campus. Buck Creek has a large culvert at its mouth that is probably a partial barrier to steelhead and coho salmon. ODFW maintains a weir that blocks fish access on Cedar Creek in the middle Sandy Basin; ODFW is currently discussing providing fish passage at this barrier. A bedrock waterfall and a water diversion structure in Alder Creek have restricted fish access for steelhead and coho; both facilities are probably partial barriers to fish passage.

Table C-1. Current and Historical Distribution of the Covered Species in the Sandy River Basin Watershed

		Fall Chinook		Spring Chinook		Winter Steelhead		Coho	
Watershed	**Reach**	Current	Historical	Current	Historical	Current	Historical	Current	Historical
Bull Run	Bull Run 1	●	○	●	○	●	○	●	○
	Bull Run 2	●	○	●	○	●	○	●	○
	Bull Run 3	●	○	●	○	●	○	●	○
	Bull Run 4	●	○	●	○	●	○	●	○
	Bull Run 5		○		○		○		○
	Bull Run 6		○		○		○		○
	Bull Run 6A		○		○		○		○
	Bull Run 7		○		○		○		○
	Bull Run 8						○		
	Bull Run 9						○		
	Bull Run 10						○		
	Bear 1						○		○
	Camp 1						○		○
	Camp 2						○		
	Cedar 1				○		○		○
	Cougar 1				○		○		○
	Cougar 2						○		
	Deer 1						○		○
	Deer 2						○		○
	Falls Creek						○		
	Fir 1						○		○
	Fir 2						○		○

● species currently present in reach ○ species was present in reach historically ○ historical presence cut off by dam

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Table C-1. Current and Historical Distribution of the Covered Species, continued

Watershed	Reach	Fall Chinook		Spring Chinook		Winter Steelhead		Coho	
		Current	Historical	Current	Historical	Current	Historical	Current	Historical
Bull Run (continued)	N. Fork Bull Run 1				○		○		○
	N. Fork Bull Run 2						○		○
	S. Fork Bull Run 1		○		○		○		○
	S. Fork Bull Run 2				○		○		○
	Little Sandy 1	●	○	●	○	●	○	●	○
	Little Sandy 2		○		○		○		○
Lower Sandy	Beaver 1A	●	○			●	○	●	○
	Beaver 1B						○		○
	Beaver 1C						○		○
	Beaver 1D						○		○
	Big 1						○		
	Buck 1						○		○
	Burlingame 1					●	○	●	○
	Gordon 1A	●	○	●	○	●	○	●	○
	Gordon 1B					●	○	●	○
	Gordon 2A					●	○	●	○
	Gordon 2B					●	○		
	Kelly 1						○		○
	Sandy 1	●	○	●	○	●	○	●	○
	Sandy 2	●	○			●	○	●	○
	Smith1					●	○		

● species currently present in reach ○ species was present in reach historically ○ historical presence cut off by dam

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Table C-1. Current and Historical Distribution of the Covered Species, continued

		Fall Chinook		Spring Chinook		Winter Steelhead		Coho	
Watershed	**Reach**	Current	Historical	Current	Historical	Current	Historical	Current	Historical
Lower Sandy (continued)	Trout 1A	●	○	●	○	●	○	●	○
	Trout 2A					●	○	●	○
	Trout 3A					●	○		
Middle Sandy	Alder 1					●	○	●	○
	Alder 1A					●	○	●	○
	Alder 2					●	○	●	○
	Cedar 1	●	○	●	○	●	○	●	○
	Cedar 2						○		○
	Cedar 3						○		○
	Cedar 4						○		○
	Sandy 3	●	○	●	○	●	○	●	○
	Sandy 4	●	○	●	○	●	○	●	○
	Sandy 5	●	○	●	○	●	○	●	○
	Sandy 6		○	●	○	●	○	●	○
	Sandy 7		○	●	○	●	○	●	○
	Wildcat 1					●	○	●	○
	Wildcat 2					●	○	●	○
	Wildcat 3					●	○		
Upper Sandy	Bear 1					●	○		
	Cast 1		○	●	○	●	○		
	Clear 1A		○	●	○	●	○	●	○
	Clear 1B			●	○	●	○	●	○
	Clear Fork 1A		○	●	○	●	○	●	○

● species currently present in reach ○ species was present in reach historically ▒○ historical presence cut off by dam

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Table C-1. Current and Historical Distribution of the Covered Species, continued

		Fall Chinook		**Spring Chinook**		**Winter Steelhead**		**Coho**	
Watershed	**Reach**	Current	Historical	Current	Historical	Current	Historical	Current	Historical
Upper Sandy (continued)	Clear Fork 1B		○	●	○	●	○	●	○
	Clear Fork 1C			●	○	●	○	●	○
	Clear Fork 1D					●	○	●	○
	Hackett 1					●	○	●	○
	Horseshoe 1					●	○		
	Lost 1A			●	○	●	○	●	○
	Lost 1B					●	○	●	○
	Muddy Fork 1					●	○		
	Muddy Fork 2					●	○		
	N. Boulder 1					●	○		
	Rushing Water 1					●	○		
	Sandy 8		○	●	○	●	○	●	○
	Sandy 9		○	●	○	●	○	●	○
	Sandy 10		○	●	○	●	○		
	Sandy 11		○	●	○	●	○		
	Sandy 12		○	●	○	●	○		
Salmon	Boulder 0		○	●	○	●	○	●	○
	Boulder 1		○	●	○	●	○	●	○
	Boulder 2		○	●	○	●	○	●	○
	Cheeney 1					●	○	●	○
	Cheeney 1A					●	○	●	○
	S. Fork Salmon 1		○	●	○	●	○	●	○
	S. Fork Salmon 2			●	○	●	○	●	○

● species currently present in reach ○ species was present in reach historically ○ historical presence cut off by dam

Table continued on next page

Table C-1. Current and Historical Distribution of the Covered Species, continued

		Fall Chinook		**Spring Chinook**		**Winter Steelhead**		**Coho**	
Watershed	**Reach**	Current	Historical	Current	Historical	Current	Historical	Current	Historical
Salmon (continued)	Salmon 1		○	●	○	●	○	●	○
	Salmon 2		○	●	○	●	○	●	○
	Salmon 3		○	●	○	●	○	●	○
	Sixes Creek 1					●	○	●	○
	Sixes Creek 2					●	○		
	Wee Burn 1					●	○	●	○
Zigzag	Camp Creek 1A		○	●	○	●	○	●	○
	Camp Creek 1B		○	●	○	●	○	●	○
	Camp Creek 1C					●	○	●	○
	Cool 1					●	○		
	Devils Canyon 1A					●	○		
	Henry 1					●	○	●	○
	Lady 1					●	○	●	○
	Little Zigzag 1					●	○		
	Still 1		○	●	○	●	○	●	○
	Still 1A		○	●	○	●	○	●	○
	Still 2		○	●	○	●	○	●	○
	Still 3			●	○	●	○		
	Wind 1			●	○	●	○	●	○
	Zigzag 1A		○	●	○	●	○		
	Zigzag 1B		○	●	○	●	○		
	Zigzag 1C			●	○	●	○		

● species currently present in reach ○ species was present in reach historically ○ historical presence cut off by dam

Source: GIS layer in EDT data model, August 8, 2006.

Appendix D. EDT Information Structure

Introduction

The Ecosystem Diagnosis and Treatment (EDT) model, developed by Mobrand Biometrics, Inc., is a tool for evaluating the productivity and carrying capacity of a basin's fisheries (Lestelle et al. 1996). Productivity is defined as a population's change in numbers over time in the absence of competition between individuals of the population. The carrying capacity of a population is defined in EDT as the maximum number of individuals that a population's habitat can support.

In the presence of competition, a population's actual change in numbers is determined by its productivity and how close it is to its carrying capacity. The EDT model draws on a database of habitat attributes and a set of mathematical algorithms to predict both the survival (determining, in part, potential productivity) and carrying capacity within a watershed for specific fish species. The model produces estimates of a population's productivity, carrying capacity, equilibrium population size, and life-history diversity on the scale of the Sandy River, and generates limiting-factors analyses on the scale of individual reaches (reaches size is defined by the user). EDT is a deterministic model that produces estimates that do not have confidence intervals.

For the purposes of this Habitat Conservation Plan (HCP), EDT provides estimates of fish productivity, diversity, and abundance in the Sandy River Basin based on 46 habitat attributes related to hydrology, water temperature, channel and streambed morphology, the richness of the biological community, riparian conditions, physical habitat conditions (e.g., relative quantity of pool, riffle, or glide habitat), water quality, and some additional factors, such as the presence of pathogens or competition with hatchery fish. EDT estimates are primarily used in two chapters of this HCP. In Chapter 5, they are used for the limiting factors analysis. They are also used in Chapter 8 for the Population Effects and VSP Parameters, and the Population Effects and Benchmark Comparison of Fish Abundance sections of the effects analysis. All model estimates are for Sandy River fish populations.

Information in the EDT model is organized on three levels:

> Level 1—fundamental stream characteristics, relatively beyond the influence of individual restoration activities
>
> Level 2—environmental attributes, mutable by individual restoration activities
>
> Level 3—survival factors

Level 1 characteristics are used to create a broad-brush profile of a watershed. They consist of a wide range of data types such as general geomorphic characterizations, descriptions of flow regime, sediment load, temperature, land use, and ownership.

Level 2 environmental attributes provide a more refined depiction of the aquatic environment. They are the measurable physical and biological characteristics of the environment that are relevant to salmonids at the reach level and that can vary within the context of a given set of Level 1 stream characteristics.

Level 3 survival factors are umbrella groups that organize the Level 2 environmental attributes into broader concepts of habitat conditions for each species under study. The Level 3 survival factors describe the biological performance of a species in relation to the state of the environment as described in the Level 2 environmental attributes.[1]

The Level 3 factors are determined from rule sets derived from scientific literature (see Lestelle et al. 2004) and have been compiled using the expert judgment of the following scientists:

- Larry Lestelle
- Lars Mobrand
- Kevin Malone
- Greg Blair
- Bruce Watson

The relationship of the Levels 2 environmental attributes in EDT for the sediment load survival factor is illustrated in Figure D-1. Figure D-1 does not represent the entire EDT model, but rather illustrates how rule sets are used, with Level 2 environmental attributes as inputs, to determine Level 3 survival factors.

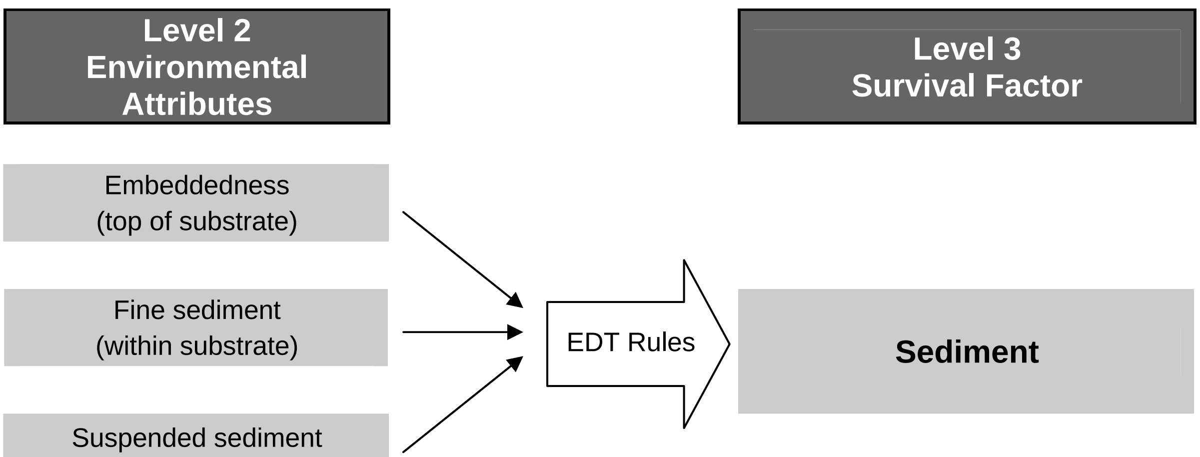

Figure D-1. Relationship of Level 2 Environmental Attributes to Level 3 Survival Factors in EDT

Table D-1, on the following pages, shows the 46 Level 2 attributes used in the analysis of the Sandy River Basin stream reaches. The table lists the variable name as it appears in the EDT database and model output, the full name of the attribute, and the definition of the attribute.

Table D-2 lists the 16 Level 3 survival factors and provides a description for each survival factor.

[1] These survival factors correspond to the types of factors typically referred to by biologists as limiting factors.

Table D-3 shows the relationship of Level 3 survival factors and Level 2 environmental attributes at different life stages for Chinook, coho, and steelhead in the Sandy River Basin.

For more information on the EDT model, see Lestelle et al. 2004; City of Portland Bureau of Water Works 2004; and Lestelle et al. 1996.

Strengths and Weaknesses of the EDT model

The Independent Scientific Advisory Board (ISAB) of the Northwest Power and Conservation Council concluded that the major strength of EDT is as follows:

"EDT accounts for cumulative effects of factors such as spatial temporal interactions, all attributes, competition, and predation effects. Density dependent factors are included. It translates combinations of actions at any scale into biological performance responses (population productivity, abundance, and life history diversity." (2001)

The ISAB also noted that EDT is a flexible model that links habitat conditions to ecological function and eventually to the biological performance of the species of interest (ISAB 2001).

EDT is best used for developing working hypothesis for how changes to stream habitat result in a change in species performance. These hypotheses are then tested over time through the use of well designed monitoring programs. This is the approach taken by the City of Portland (City) in this HCP.

The ISAB (2001) also noted that EDT weaknesses are the *"…lack of ground truthing of input data and peer review to ensure that rules are consistent with current information and knowledge."*

The SRBTT used the following methods to ensure the validity of the data:

- The input data for the Sandy River stream reaches predominantly came from recent stream surveys.
- The biologists on the Sandy River Basin Agreement Technical Team (SRBTT) checked all data before creating EDT reach ratings for the habitat attributes.

About half (52 percent) of input data for both historical and present habitat conditions in Sandy River Basin stream reaches were based on empirical measurements or extrapolations from empirical measurements in neighboring reaches. Local biologists with expert knowledge contributed information that was used to derive an additional 27 percent of the EDT input data. The remaining 21 percent of input data, mostly concerning historical conditions, were based on a review of similar Cascade streams. After the initial EDT model runs were done, biologists then reviewed the results and made corrections to the reach ratings as appropriate.

The EDT model and its biological rules have been offered to many agencies for peer review. The ISAB reviewed the model for the Northwest Power and Conservation Council and found the biological rules to be adequate for prioritizing habitat actions in a basin. Since the ISAB review was completed in 2001, the EDT model has been used by biologists throughout the region for developing subbasin plans for the Northwest Power and Conservation Council. Through this process, many of the rules in EDT have been updated and refined.

These updates are included in the version of the model the City used for modeling fish populations in the Sandy River Basin for the HCP.

The National Marine Fisheries Service (NMFS), through its Science Center, is currently doing a sensitivity analysis on the EDT model. NMFS has not found much criticism of the model's biological rules, but was concerned about the large number of model inputs and resulting output variability. NMFS has determined that there can be high variability around the model outputs resulting from high variability around the inputs, specifically the reach habitat ratings and the out-of-basin survival factors such as ocean conditions.

The Washington Department of Fish and Wildlife (WDFW) also conducted a sensitivity analysis on EDT model runs for Puget Sound basins using Monte Carlo statistical techniques (WDFW 2006). WDFW found the EDT model output variability was generally low, although higher levels were observed occasionally. The simulations yielded variations of approximately 4 percent to 11 percent for EDT estimates of productivity, capacity, and abundance. In addition, WDFW found that EDT rankings of a river reach's relative restoration and protection value for Chinook salmon were quite stable for the highest ranked reaches.

As noted above, EDT is a deterministic model, not a statistical model, so does not provide a measure of confidence to accompany its estimates.

Table D-1. EDT Level 2 Environmental Attributes

Variable Name	Attribute	Definition
Alka	Alkalinity	Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/L of either HCO3 or CaCO3.
BdScour	Bed scour	Average depth of bed scour in salmonid spawning areas (i.e., in pool tail-outs and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).
BenComRch	Benthos diversity and production	Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of Oregon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).
ChLngth	Channel length	Length of the primary channel contained with the stream reach. Note: this attribute will not be given by categories but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.
WidthMx	Channel width – month maximum width (ft)	Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.
WidthMn	Channel width – month minimum width (ft)	Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Table continued on next page

Table D-1. EDT Level 2 Environmental Attributes, continued

Variable Name	Attribute	Definition
ConfineHdro	Confinement – Hydromodifications	The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called "headcutting"). Flow access to the floodplain can be partially or wholly cutoff due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees—consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.
Confine	Confinement – natural	The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankfull channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.
DisOxy	Dissolved oxygen	Average dissolved oxygen within the water column for the specified time interval.
Emb	Embeddedness	The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tail-out habitat units and only where cobble or gravel substrates occur.
FnSedi	Fine sediment	Percentage of fine sediment within salmonid spawning substrates, located in pool tail-outs, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1 mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.
FshComRch	Fish community richness	Measure of the richness of the fish community (number of fish taxa, i.e., species).
FshPath	Fish pathogens	The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.

Table continued on next page

Table D-1. EDT Level 2 Environmental Attributes, continued

Variable Name	Attribute	Definition
FSpIntro	Fish species introductions	Extent of introductions of exotic fish species in the vicinity of the stream reaches under consideration.
FlwHigh	Flow – change in average annual peak flow	The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).
FlwLow	Flow – change in average annual low flow	The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically based where sufficiently long data series exists, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.
FlwDielVar	Flow – Intra daily (diel) variation	Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.
FlwIntraAnn	Flow – intra-annual flow pattern	The average extent of intra-annual flow variation during the wet season—a measure of a stream's "flashiness" during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.
Grad	Gradient	Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.
HbBckPls	Habitat type – backwater pools	Percentage of the wetted channel surface area comprising backwater pools.
HbBvrPnds	Habitat type – beaver ponds	Percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat.

Table continued on next page

Table D-1. EDT Level 2 Environmental Attributes, continued

Variable Name	Attribute	Definition
HbGlide	Habitat type – glide	Percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.
HbLrgCbl	Habitat type – large cobble/boulder riffles	Percentage of the wetted channel surface area comprising large cobble/boulder riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).
HbOfChFctr	Habitat type – off-channel habitat factor	A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.
HbPlTails	Habitat type – pool tailouts.	Percentage of the wetted channel surface area comprising pool tailouts.
HbPls	Habitat type – primary pools	Percentage of the wetted channel surface area comprising pools, excluding beaver ponds.
HbSmlCbl	Habitat type – small cobble/gravel riffles	Percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).
Harass	Harassment	The relative extent of poaching and/or harassment of fish within the stream reach.
HatFOutp	Hatchery fish outplants	The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. "Drainage" here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.
HydroRegimeNatural	Hydrologic regime – natural	The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.
HydroRegimeReg	Hydrologic regime – regulated	The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (see Flow-Intra-daily variation attribute).

Table continued on next page

Table D-1. EDT Level 2 Environmental Attributes, continued

Variable Name	Attribute	Definition
Icing	Icing	Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short term. It is recognized that icing events can under some conditions have long-term beneficial effects to habitat structure.
MetWatCol	Metals – in water column	The extent of dissolved heavy metals within the water column.
MetSedSls	Metals/Pollutants – in sediments/soils	The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.
MscToxWat	Miscellaneous toxic pollutants – water column	The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.
NutEnrch	Nutrient enrichment	The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macro-nutrients that enrich streams and cause build ups of algae. These conditions, in addition to leading to other adverse conditions, such as low DO can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be applied when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.
Obstr	Obstructions to fish migration	Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).
PredRisk	Predation risk	Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish-eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude, and frequency of exposure to potential predators (assuming other habitat factors are constant). Note: This attribute is being updated to distinguish risk posed to small bodied fish (<10 in) from that to large bodied fish (>10 in).
RipFunc	Riparian function	A measure of riparian function that has been altered within the reach.
SalmCarcass	Salmon Carcasses	Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs. the upper mainstem, or in mainstem areas vs. major tributary drainages.
TmpMonMx	Temperature – daily maximum (by month)	Maximum water temperatures within the stream reach during a month.
TmpMonMn	Temperature – daily minimum (by month)	Minimum water temperatures within the stream reach during a month.

Table continued on next page

Table D-1. EDT Level 2 Environmental Attributes, continued

Variable Name	Attribute	Definition
TmpSptVar	Temperature – spatial variation	The extent of water temperature variation (cool or warm water depending upon season) within the reach as influenced by inputs of groundwater or tributary streams, or the presence of thermally stratified deep pools.
Turb	Turbidity	The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids; hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended solids, including very fine particles such as clays and colloids and some dissolved materials, cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/L. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/l, a = 1.0642 , b = 0.6068, and c = 0.7384. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.
Wdrwl	Water withdrawals	The number and relative size of water withdrawals in the stream reach.
WdDeb	Wood	The amount of wood (large woody or LW) within the reach. Dimensions of what constitutes LW are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LW corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LW pieces/CW and presence of jams (on larger channels). Reference to "large" pieces in index values uses the standard TFW definition as those > 50 cm diameter at midpoint.

Source: Lestelle et al. 2004s

Table D-2. EDT Level 3 Survival Factors

Factor	Description
Channel stability	Stability of the reach with respect to its stream bed, banks, and its channel shape and location. The more unstable the channel, the lower the survival of eggs and juvenile fish.
Stream Flow	The amount, pattern, or extent of stream flow fluctuations. Both too much and too little flow in the stream channel can reduce salmon performance. High flows may cause juveniles to leave a stream, low flows may eliminate all production from the stream.
Habitat diversity	The extent of habitat complexity within a stream reach. Complexity is the opposite of uniformity; greater complexity increases survival. Streams with large amounts of wood, boulders, undercut banks, and pools provide better habitat than those that do not.
Sediment Load	The amount of sediment present in or passing through the stream reach. Fine sediment can smother incubating eggs and reduce the quality of juvenile rearing habitat.
Stream Temperature	Water that is too cold or hot can reduce salmon survival at all life stages. In general, fish sensitivity to temperature decreases as fish move from egg to smolt to adult.
Predation	The relative abundance of predators that feed upon fish. Predators can be fish, mammals, or birds.
Chemicals	Concentrations of toxic chemicals and conditions (such as pH) from point and non-point sources.
Competition With Other Species	The relative abundance of other species that compete with salmon for food and space in the same stream reach.
Competition with Hatchery Fish	The relative abundance of hatchery fish that compete with salmon for food and space in the same stream reach.
Obstructions	Physical structures, such as dams, weirs, or waterfalls, that impede the use of a stream reach by fish.
Water Withdrawals	Water removed from stream channels for irrigation, city water supply, or other uses. Water removal can affect fish by entraining juveniles on pump intakes or lowering water levels. Low water levels can impede fish passage, reduce available habitat, and result in high water temperatures.
Food	The amount, diversity, and availability of food available to the fish community. Food sources include macroinvertebrates, salmon carcasses, and terrestrial insects.
Oxygen	Mean concentration of dissolved oxygen in the stream reach. Low oxygen levels reduce fish survival at all life stages.
Pathogens	The abundance, concentration, or effects of pathogens on fish in the stream reach. For example, the presence of a fish hatchery or large numbers of livestock along the reach could cause unusually high concentrations of pathogens.
Key Habitat	The amount of the key habitat present in the stream for each life stage. An example of key habitat would be riffles in which salmonids spawn. If key habitats are limited, fewer salmon can be supported by the stream.
Harassment/Poaching	Humans may reduce the survival of salmonids though such activities as swimming, boating, and poaching, i.e., catching fish illegally. The effects of legal harvest on salmonids are not considered in this factor.

Source: Lestelle et al. 2004

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Table D-3. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
Spawning	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - Intra daily (diel) variation						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Small cobble/gravel riffles	Pool tailouts	Glides				
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	no effects						
Incubation	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals/Pollutants - in sediments/soils	Metals - in water column				

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon. Source: Mobrand Biometrics, Inc., 2004

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - Intra daily (diel) variation						
	Food	no effects						
	Habitat diversity	No effect						
	Harassment	Harassment						
	Key Habitat	Small cobble/gravel riffles	Pool tailouts	Glides				
	Obstructions	No effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	No effect						
	Sediment load	Fine sediment						
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	No effects						
Fry colonization	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effects						
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - change in intra-annual variability (flow flashiness)	Riparian function	Wood

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Icing	
	Harassment	no effects						
	Key Habitat	Backwater pools	Beaver ponds	Primary pools	Pool tailouts	Glides	Small cobble/gravel riffles	Large cobble riffles
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Embeddedness					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications
	Flow (continued)		Riparian function	Wood				
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Primary pools	Backwater pools	Glides	Pool tailouts	Beaver ponds	Large cobble riffles	Off-channel habitat (just coho)
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age transient rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications
	Flow (continued)		Riparian function	Wood				
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
	Key Habitat	Primary pools	Backwater pools	Glides	Pool tailouts	Beaver ponds	Large cobble riffles	
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	no effects						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	no effects						
	Key Habitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						

Source: Mobrand Biometrics, Inc., 2004

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age Inactive	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - change in intra-annual variability (flow flashiness)	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment						
	Key Habitat	Primary pools	Backwater pools	Beaver ponds	Glides	Large cobble riffles just chinook		
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily minimum (by	Hatchery fish outplants		

Source: Mobrand Biometrics, Inc., 2004

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
					month)			
	Sediment load	Embeddedness	Turbidity (susp. sed.)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - change in intra-annual variability (flow flashiness)	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Primary pools	Backwater pools	Glides	Pool tailouts	Beaver ponds	Large cobble riffles	
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	no effects						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	no effects						
	Key Habitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
Prespawning migrant	Channel stability	no effects						

Source: Mobrand Biometrics, Inc., 2004

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - changes in interannual variability in low flows						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - Hydromodifications	Riparian function	Wood			
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration2						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	no effects						
Prespawning holding	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Competition (with other species)	no effects						
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications
	Flow (continued)		Riparian function	Wood				
	Food	no effects						
	Habitat diversity	Gradient	Confinement - Hydromodifications	Riparian function	Wood			
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Primary pools	Glides	Large cobble riffles				
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	no effects						

Table D-4. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
Spawning	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - Intra daily (diel) variation						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Small cobble/gravel riffles	Pool tailouts	Glides				
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	no effects						
Incubation	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals/Pollutants - in sediments/soils	Metals - in water column				

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - Intra daily (diel) variation						
	Food	no effects						
	Harassment	Harassment						
	Key Habitat	Small cobble/gravel riffles	Pool tailouts	Glides				
	Obstructions	No effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Sediment load	Fine sediment						
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	No effects						
Fry colonization	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effects						
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - change in intra-annual variability (flow flashiness)	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Icing	

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Harassment	no effects						
	Key Habitat	Backwater pools	Beaver ponds	Primary pools	Pool tailouts	Glides	Small cobble/gravel riffles	Large cobble riffles
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Embeddedness					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications
	Flow (continued)		Riparian function	Wood				
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Primary pools	Backwater pools	Glides	Pool tailouts	Beaver ponds	Large cobble riffles	Off-channel habitat

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Key Habitat (continued)		Small cobble/gravel riffles					
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	no effects						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	no effects						
	Key Habitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age Inactive	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - change in intra-annual variability (flow flashiness)	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment						
	Key Habitat	Primary pools	Backwater pools	Beaver ponds	Glides	Off-channel habitat		
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily minimum (by	Hatchery fish outplants		

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
					month)			
	Sediment load	Embeddedness	Turbidity (susp. sed.)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - change in intra-annual variability (flow flashiness)	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Primary pools	Backwater pools	Glides	Pool tailouts	Beaver ponds	Large cobble riffles	Small cobble/gravel riffles
	Key Habitat (continued)		Off-channel habitat					
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by					

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
			month)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	no effects						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	no effects						
	Key Habitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
Prespawning migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - changes in interannual variability in low flows						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - Hydromodifications	Riparian function	Wood			
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	no effects						
Prespawning holding	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications
	Flow (continued)		Riparian function	Wood				
	Food	no effects						
	Habitat diversity	Gradient	Confinement - Hydromodifications	Riparian function	Wood			
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Primary pools	Glides	Large cobble riffles				
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	no effects						

Table D-5. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
Spawning	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	Flow - Intra daily (diel) variation						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	Habitat type- small cobble/gravel riffles	Habitat type- pool tailouts	Habitat type-glides				
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
Incubation	Channel stability	Bed scour	Icing	Riparian function	Wood	Confinement - Hydromodifications	Flow - change in interannual variability in high flows	Flow - intra-annual flow pattern
	Chemicals	Miscellaneous toxic pollutants - water	Metals/Pollutants - in sediments/soils	Metals - in water column				

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
		column						
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	Flow - Intra daily (diel) variation	Flow - change in interannual variability in low flows					
	Food	no effects						
	Habitat diversity	No effect						
	Harassment	Harassment						
	KeyHabitat	Habitat type- small cobble/gravel riffles	Habitat type- glides	Habitat types- pool tailouts				
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	No effect						
	Sediment load	Fine sediment						
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
Fry colonization	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		

Source: Mobrand Biometrics, Inc., 2004

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - intra-annual flow pattern	Riparian function	Wood
	Food	Alkalinity	Benthos diversity	Riparian function	Salmon Carcasses			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Icing	
	Harassment	no effects						
	KeyHabitat	Habitat type- backwater pools	Habitat type- beaver ponds	Habitat type- large cobble/boulder riffles	Habitat type- primary pools	Habitat type- small cobble/gravel riffle	Habitat type- glides	Habitat type- pool tailouts
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Embeddedness					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Riparian function	Wood	Confinement - Hydromodifications	Confinement - natural	Confinement - Hydromodifications

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Food	Alkalinity	Benthos Diversity	Riparian function	Salmon Carcasses			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	No effect						
	Food	no effects						
	Habitat diversity	Riparian function	Confinement - natural	Confinement - Hydromodifications	Wood			
	Harassment	No effect						

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead tro

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Key Habitat	Habitat type- backwater pools	Habitat type- beaver ponds	Habitat type- glides	Habitat type-large cobble/boulder riffles	Habitat type- pool tailouts	Habitat type- primary pools	Habitat type- small cobble/gravel riffles
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temper1ature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age Inactive	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow-intra-annual flow pattern	Riparian function	Wood
	Food	Benthos diversity and production	Alkalinity	Riparian function	Salmon Carcasses			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Icing	
	Harassment	Harassment						
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily minimum (by month)	Hatchery fish outplants		
	Sediment load	Embeddedness	Turbidity (susp. sed.)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow- intra-annual flow pattern	Riparian function	Wood
	Food	Alkalinity	Benthos diversity	Riparian function	Salmon Carcasses			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Icing	
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	no effects						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Icing	
	Harassment	Harassment						
	KeyHabitat	Habitat type- backwater pools	Habitat type- beaver ponds	Habitat type- glides	Habitat type- large cobble/boulder riffles	Habitat type-pool tailouts	Habitat type- primary pools	Habitat type- small cobble/gravel riffles
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age inactive	Channel stability	Bed Scour	Icing	Riparian Function	Wood			
	Chemicals	Misc toxic pollutants- water column	Metals/Pollutants- in sediments/soils	Metals- in water column				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	Flow- change in interannual variability in high flows	Confinement- Hydromodifications	Confinement- natural	Gradient	Flow- intra-annual flow pattern	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity	Riparian function			
	Habitat diversity	Gradient	Confinement- Hydromodifications	Confinement- natural	Riparian Function	Wood		
	Harassment	No effect						
	KeyHabitat							
	Obstructions							
	Oxygen	Dissolved Oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature- daily Max (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature- daily Min (by month)	Hatchery fish outplants		
	Sediment load	Embeddedness	Turbidity					
	Temperature	Temperature- daily Min (by month)	Temperature- spatial variation					
	Withdrawals	Water withdrawals						

Source: Mobrand Biometrics, Inc., 2004

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
2+ age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Misc toxic pollutants- water column	Metals/Pollutants- in sediments/soils	Metals- in water column				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity	Riparian function	Salmon Carcasses		
	Flow	Flow- change in interannual variability in high flows	Confinement- Hydromodifications	Confinement- natural	Gradient	Flow- intra-annual flow pattern	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity	Riparian function			
	Habitat diversity	Gradient	Confinement- Hydromodifications	Confinement- natural	Riparian function	Wood		
	Harassment	Harassment	Habitat type- primary pools	Riparian function	Turbidity	Wood		
	KeyHabitat							
	Obstructions							
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature- daily Max (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature- daily Max (by month)			
	Sediment load	Turbidity	Temperature- daily Max (by month)					
	Temperature	Temperature- daily Max (by month)	Temperature- daily Min (by month)	Temperature- spatial variation				
	Withdrawals	Water withdrawals						
2+ age migrant	Channel stability	No effect						
	Chemicals	Misc toxic pollutants- water column	Metals/Pollutants- in sediments/soils	Metals- in water column				

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	No effect						
	Food	No effect						
	Habitat diversity	Riparian function	Confinement- Hydromodifications	Confinement- natural	Wood			
	Harassment	No effect						
	Key Habitat	Habitat type- backwater pools	Habitat type- beaver ponds	Habitat type- glides	Habitat type- large cobble/boulder riffles	Habitat type- pool tailouts	Habitat type- primary pools	Habitat type- small cobble/gravel riffles
	Obstructions							
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature- daily Max (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature- daily Max (by month)	Hatchery fish outplants		
	Sediment load	Turbidity	Temperature- daily Max (by month)					
	Temperature	Temperature- daily Max (by month)	Temperature- spatial variation					
	Withdrawals	Water withdrawals						
2+ age inactive	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Misc toxic pollutants- water column	Metals/Pollutants- in sediments/soils	Metals- in water column				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	Flow- change in interannual variability in high	Confinement- Hydromodifications	Confinement- natural	Gradient	Flow- intra-annual flow pattern	Riparian function	Wood

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trou

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
		flows						
	Food	Alkalinity	Salmon Carcasses	Benthos diversity	Riparian function			
	Habitat diversity	Gradient	Confinement-Hydromodifications	Confinement-natural	Riparian function	Wood		
	Harassment	No effect						
	KeyHabitat							
	Obstructions							
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature- daily Max (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature- daily Min (by month)	Hatchery fish outplants		
	Sediment load	Embeddedness	Turbidity					
	Temperature	Temperature- daily Min (by month)	Temperature- spatial variation					
	Withdrawals	Water withdrawals						
Prespawning migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	Flow - changes in interannual variability in low flows						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	Habitat type- backwater pools	Habitat type- beaver ponds	Habitat type- glides	Habitat type- large cobble/boulder riffles	Habitat type- pool tailouts	Habitat type- primary pools	Habitat type-small cobble/gravel riffles
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	No effects						
Prespawning holding	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effects						
	Competition (with other species)	No effects						
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications
	Flow (cont)		Riparian function	Wood				
	Food	no effects						
	Habitat diversity	Gradient	Confinement - Hydromodifications	Riparian function	Wood			

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	Habitat type- primary pools	Habitat type- glides	Habitat type- large cobble/boulder riffles				
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	No effect						

Source: Mobrand Biometrics, Inc., 2004

Appendix E. Offsite Habitat Effects Tables

Introduction

In the Chapter 8 subsection "Habitat Effects in the Sandy River Basin from the HCP Offsite Measures," habitat benefits tables show the projected trends in the reference conditions (e.g., improvement, increase, decrease, etc.) for each of the four primary covered fish species. To supplement the trend information, the tables in this appendix show the expected numeric habitat benefits for each of the primary covered fish species.

Habitat benefits derived from instream projects are expected to accrue within five years. The instream projects will be implemented over the first 11 years of the Habitat Conservation Plan (HCP). Instream projects that involve placing large wood will be designed to have an estimated life span of 15 years. Benefits from these projects will, therefore, begin decreasing after 15 years, but are expected to be completely offset by increasing benefits derived from riparian easements.

Habitat benefits derived from riparian easements and improvements are expected to begin accruing after 15 years and take up to 30 years to be fully realized. Riparian easements will be implemented over the first 15 years of the HCP. The cumulative benefits summarized in the tables in this appendix, therefore, are expected to be accomplished at staggered intervals throughout the life of the HCP and fully attained by 30 years after the last riparian easement is implemented.

Habitat Benefits Effects Tables

The habitat benefit tables in this appendix, Tables E-6 through E-20, show the current condition, habitat benefits as a percentage improvement, and the expected post-implementation condition for each of the four primary covered species. Definitions for all of the habitat benefits are provided in Table D-1 of Appendix D in this HCP.

The current condition for each stream reach was input into the Ecosystem Diagnosis and Treatment (EDT) model from data gathered during stream surveys conducted in the 1990s. The current and post-implementation conditions are expressed as percentages, units per measure of habitat (e.g., number of pieces of large wood (LW) per channel width), or EDT scores. The EDT scores are ratings from 0 to 4 in which 0 represents optimal conditions (zero negative impact), and 4 represents extremely poor, or lethal, conditions for fish. The EDT scores are based on index values that are provided below.

EDT Score Index Values

In the habitat benefits tables for each species, five habitat conditions are expressed as EDT scores: maximum water temperature, minimum water temperature, temperature moderation by groundwater, fish pathogens, and harassment. The following tables show the index values that are the numeric basis for the EDT scores shown in the habitat benefits tables. The EDT maximum water temperature scores are based on the index values shown in Table E-1.

Table E-1. Index Values for EDT Maximum Water Temperature Scores

EDT Score	Index Values
0	warmest day with a maximum temperature <10°C
1	warmest day with temperatures >10°C and < 16°C
2	• more than 1 day with temperatures of 22–25°C *or* • 1–12 days with temperatures >16°C
3	• more than 1 day with temperatures of 25–27.5°C *or* • more than 4 non-consecutive days with temperatures during the warmest day of 22–25°C *or* • more than 12 days with temperatures >16°C
4	• more than 1 day with temperatures of >27.5°C *or* • 3 consecutive days with temperatures of >25°C *or* • more than 24 days with maximum temperatures >21°C

Source: Lestelle et al. 2004

The EDT minimum water temperature scores are based on the index values shown in Table E-2.

Table E-2. Index Values for EDT Minimum Water Temperature Scores

EDT Score	Index Values
0	Coldest day with a minimum temperature >4°C
1	Fewer than 7 days with temperatures < 4°C and >1°C
2	Between 1 and 7 days with minimum temperatures of < 1°C
3	Between 8 and 15 days with minimum temperatures of < 1°C
4	More than 15 winter days with minimum temperatures of < 1°C

Source: Lestelle et al. 2004

The EDT temperature moderation by groundwater scores are based on the index values shown in Table E-3.

Table E-3. Index Values for EDT Temperature Moderation by Groundwater Scores

EDT Score	Index Values
0	Super-abundant sites of groundwater discharge into surface waters (primary source of streamflow), tributaries entering reach, or deep pools that provide abundant temperature variation in reach
1	Abundant sites of groundwater discharge into surface waters, tributaries entering reach, or deep pools that provide abundant temperature variation in reach
2	Occasional sites of groundwater discharge into surface waters, tributaries entering reach, or deep pools that provide intermittent temperature variation in reach
3	Infrequent sites of groundwater discharge into surface waters, tributaries entering reach, or deep pools that provide intermittent temperature variation in reach
4	No evidence of temperature variation in reach

Source: Lestelle et al. 2004

The EDT fish pathogen scores are based on the index values shown in Table E-4.

Table E-4. Index Values for EDT Fish Pathogen Scores

EDT Score	Index Values
0	No historic or recent fish stocking in drainage and no known incidence of whirling disease, Ceratomyxa shasta (C. shasta), infectious hematopoietic necrosis Virus (IHN), or infectious pancreatic necrosis (IPN)
1	Historic fish stocking, but no fish stocking records within the past decade, or sockeye population currently existing in drainage, or known incidence of viruses among kokanee populations within the watershed
2	Ongoing periodic, frequent, or annual fish stocking in drainage or known viral incidence within sockeye, Chinook, or steelhead populations in the watershed
3	Operating hatchery within the reach or in the reach immediately downstream or upstream
4	Known presence of whirling disease or C. shasta within the watershed

Source: Lestelle et al. 2004

The EDT harassment scores are based on the index values shown in Table E-5.

Table E-5. Index Values for EDT Harassment Scores

EDT Score	Index Values
0	Reach is distant from human population centers, no road access or no local concentration of human activity
1	Reach is distant from human population centers, but with partial road access or little local concentration of human activity
2	Reach is near human population center, but has limited public access (through roads or boat launching sites)
3	Extensive road and/or boat access to the reach with localized concentrations of human activity
4	Reach is near human population center or has extensive recreational activities, and has extensive road access and/or opportunities for boat access

Source: Lestelle et al. 2004

Habitat Benefits for Fall Chinook

Table E-6. Habitat Benefits for Fall Chinook in the Lower Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Beaver 1A	63% of full riparian function	3% improvement	65% of full riparian function
	0.7 pieces LW per channel width	21% increase	0.8 pieces LW per channel width
Gordon 1A	24% surface area of gravel patches is fine sediment	25% decrease	18% surface area of gravel patches is fine sediment
	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	30% of total habitat is large-cobble riffles	17% decrease	25% of total habitat is large-cobble riffles
	14% of total habitat is pool habitat	115% increase	30% of total is pool habitat
	3% of total habitat is pool-tail habitat	46% increase	5% of total habitat is pool-tail habitat
	52% of total habitat is small-cobble riffles	33% decrease	35% of total habitat is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Sandy 1	25% artificial confinement	20% reduction	20% artificial confinement
	63% of full riparian function	19% improvement	75% of full riparian function
	6.5 pieces LW per channel width	35% increase	8.8 pieces LW per channel width
Sandy 2	38% of full riparian function	69% improvement	64% of full riparian function
	EDT maximum water temperature score of 3	3% decrease in the score	EDT maximum water temperature score of 2.9
	6.5 pieces LW per channel width	121% increase	14.4 pieces LW per channel width
Trout 1A	1.5 pieces LW per channel width	7% increase	1.6 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b]When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Beaver 1A riparian function, the current condition of 63% will be improved by 3% to give 0.63+(0.63*0.03)=0.65.

Table E-7. Habitat Benefits for Fall Chinook in the Middle Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Cedar 1	7 mg/l of dissolved oxygen	14% increase	8 mg/l of dissolved oxygen
	EDT fish pathogen score of 2	20% improvement	EDT fish pathogen score of 1.6
	EDT minimum water temperature score of 1	20% decrease in the score	EDT minimum water temperature score of 0.8
	EDT score of 2 in the maximum water temperature score	20% decrease in the score	EDT score of 1.6 in the maximum water temperature score
	EDT temperature moderation by groundwater score of 3	33% improvement in the score	EDT temperature moderation by groundwater score of 2
Sandy 3	83% of full riparian function	5% improvement	87% of full riparian function
	EDT score of 3 in the maximum water temperature score	1% decrease in the score	EDT score of 2.97 in the maximum water temperature score
	2.0 pieces LW per channel width	31% increase	2.6 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Sandy 3 riparian function, the current condition of 83% will be improved by 5% to give 0.83+(0.83*0.05)=0.87.

Habitat Benefits for Spring Chinook

Table E-8. Habitat Benefits for Spring Chinook in the Lower Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Gordon 1A	24% surface area of gravel patches is fine sediment	25% decrease	18% surface area of gravel patches is fine sediment
	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	30% of total habitat is large-cobble riffles	17% decrease	25% of total habitat is large-cobble riffles
	14% of total habitat is pool habitat	115% increase	30% of total is pool habitat
	3% of total habitat is pool-tail habitat	46% increase	5% of total habitat is pool habitat
	52% of total habitat is small-cobble riffles	33% decrease	35% of total habitat is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Gordon 1B	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	6% of total is pool habitat	212% increase	20% of total is pool habitat
	1% of total is pool-tail habitat	326% increase	5% of total is pool-tail habitat
	58% of total is small-cobble riffles	40% decrease	35% of total is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Sandy 1	25% artificial confinement	20% reduction	20% artificial confinement
	63% of full riparian function	19% improvement	75% of full riparian function
	6.5 pieces LW per channel width	35% increase	8.8 pieces LW per channel width
Sandy 2	38% of full riparian function	69% improvement	64% of full riparian function
	EDT maximum water temperature score of 3	3% decrease in the score	EDT maximum water temperature score of 2.9
	6.5 pieces LW per channel width	121% increase	14.4 pieces LW per channel width
Trout 1A	1.5 pieces LW per channel width	7% increase	1.6 pieces LW per channel width
Trout 2A	1.5 pieces LW per channel width	13% increase	1.7 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Gordon 1A fine sediment, the current condition of 24% will be decreased by 25% to give 0.24-(0.24*0.25)=0.18.

Table E-9. Habitat Benefits for Spring Chinook in the Middle Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Cedar 1	7 mg/l of dissolved oxygen	14% increase	8 mg/l of dissolved oxygen
	EDT fish pathogen score of 2	20% improvement	EDT fish pathogen score of 1.6
	EDT minimum water temperature score of 1	20% decrease in the score	EDT minimum water temperature score of 0.8
	EDT score of 2 in the maximum water temperature score	20% decrease in the score	EDT score of 1.6 in the maximum water temperature score
	EDT temperature moderation by groundwater score of 3	33% improvement in the score	EDT temperature moderation by groundwater score of 2
Sandy 3	83% of full riparian function	5% improvement	87% of full riparian function
	EDT score of 3 in the maximum water temperature score	1% decrease in the score	EDT score of 2.97 in the maximum water temperature score
	2.0 pieces LW per channel width	31% increase	2.6 pieces LW per channel width
Sandy 7	25.0 carcasses per stream mile	70% increase [c,d]	42.5 carcasses per stream mile
	EDT score of 2 in the maximum water temperature score	2% decrease in the score	EDT score of 1.97 in the maximum water temperature score

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Sandy 3 riparian function, the current condition of 83% will be improved by 5% to give 0.83+(0.83*0.05)=0.87.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-10. Habitat Benefits for Spring Chinook in the Upper Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Sandy 8	63% of full riparian function	14% improvement	72% of full riparian function
	113 carcasses per stream mile	31% increase[c,d]	148 carcasses per stream mile
	EDT score of 2 in the maximum water temperature score	3% decrease in the score	EDT score of 1.95 in the maximum water temperature score
	2.0 pieces LW per channel width	34% increase	2.7 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Sandy 8 riparian function, the current condition of 63% will be improved by 14% to give 0.63+(0.63*0.14)=0.72.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-11. Habitat Benefits for Spring Chinook in the Salmon River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Boulder 0	24% fine sediments by surface area	5% decrease	22.8% fine sediments by surface area
	EDT maximum water temperature score of 1.5	27% decrease in the score	EDT maximum water temperature score of 1.1
	0.7 pieces LW per channel width	315% increase	2.8 pieces LW per channel width
Boulder 1	83% of full riparian function	20% improvement	100% of full riparian function
	EDT maximum water temperature score of 1.5	13% decrease in the score	EDT maximum water temperature score of 1.3
	1.5 pieces LW per channel width	133% increase	3.5 pieces LW per channel width
Salmon 1	3% of total is off-channel habitat	66% increase	4% of total is off-channel habitat
	3% of total is small-cobble riffles	54% decrease	5% of total is small-cobble riffles
	75% of full riparian function	8% improvement	81% of full riparian function
	200 carcasses per stream mile	50% increase[c,d]	300 carcasses per stream mile
	EDT maximum water temperature score of 3	21% decrease in the score	EDT maximum water temperature score of 2.36
	2.0 pieces LW per channel width	62% increase	3.2 pieces LW per channel width
Salmon 2	14.0 cm is average depth of bed scour	3% reduction	13.6 cm is average depth of bed scour
	25% artificial confinement	12% reduction	22% artificial confinement
	3% of total is off-channel habitat	90% increase	5% of total is off-channel habitat
	50% of full riparian function	33% improvement	67% of full riparian function
	EDT maximum water temperature score of 2	2% decrease in the score	EDT maximum water temperature score of 1.97
	2.0 pieces LW per channel width	67% increase	3.3 pieces LW per channel width
Salmon 3	2 pieces LW per channel width	90% increase in the amount of LW	3.8 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Boulder 0 fine sediments, the current condition of 24% will be decreased by 5% to give 0.24-(0.24*0.05)=0.228.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-12. Habitat Benefits for Spring Chinook in the Zigzag River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Zigzag 1A	40% artificial confinement	38% reduction	25% artificial confinement
	EDT harassment score of 1.5	14% improvement in the score	EDT harassment score of 1.29
	20% of total habitat is large-cobble riffles	20% decrease	15% of total habitat is large-cobble riffles
	55% of total habitat is small-cobble riffles	4% increase	57% of total habitat is small-cobble riffles
	15% of total habitat is pools	15% increase	17% of total habitat is pools
	3% of total habitat is pool-tails	27% increase	4% of total habitat is pool-tails
	63% of full riparian function	7% improvement	68% of full riparian function
	113 carcasses per stream mile	167% increase[c]	300 carcasses per stream mile
	0.7 pieces LW per channel width	323% increase	2.8 pieces LW per channel width
Zigzag 1B	113 carcasses per stream mile	167% increase [c]	300 carcasses per stream mile
Zigzag 1C	13 carcasses per stream mile	100% increase [c]	25 carcasses per stream mile

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Zigzag 1A artificial confinement, the current condition of 40% will be reduced by 38% to give 0.40-(0.40*0.38)=0.25.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

Habitat Benefits for Winter Steelhead

Table E-13. Habitat Benefits for Winter Steelhead in the Lower Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Beaver 1A	63% of full riparian function	3% improvement	65% of full riparian function
	0.7 pieces LW per channel width	21% increase	0.8 pieces LW per channel width
Gordon 1A	24% surface area of gravel patches is fine sediment	25% decrease	18% surface area of gravel patches is fine sediment
	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	30% of total habitat is large-cobble riffles	17% decrease	25% of total habitat is large-cobble riffles
	14% of total is pool habitat	115% increase	30% of total is pool habitat
	3% of total habitat is pool-tail habitat	46% increase	5% of total habitat is pool-tail habitat
	52% of total habitat is small-cobble riffles	33% decrease	35% of total habitat is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Gordon 1B	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	6% of total is pool habitat	212% increase	20% of total is pool habitat
	1% of total is pool-tail habitat	326% increase	5% of total is pool-tail habitat
	58% of total is small-cobble riffles	40% decrease	35% of total is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Sandy 1	25% artificial confinement	20% reduction	20% artificial confinement
	63% of full riparian function	19% improvement	75% of full riparian function
	6.5 pieces LW per channel width	35% increase	8.8 pieces LW per channel width
Sandy 2	38% of full riparian function	69% improvement	64% of full riparian function
	EDT maximum water temperature score of 3	3% decrease in the score	EDT maximum water temperature score of 2.9
	6.5 pieces LW per channel width	121% increase	14.4 pieces LW per channel width
Trout 1A	1.5 pieces LW per channel width	7% increase	1.6 pieces LW per channel width
Trout 2A	1.5 pieces LW per channel width	13% increase	1.7 pieces LW per channel width

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Beaver 1A riparian function, the current condition of 63% will be improved by 3% to give 0.63+(0.63*0.03)=0.65.

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

Table E-14. Habitat Benefits for Winter Steelhead in the Middle Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Alder 1	Partial barrier at RM 0.1		Access to 1.6 river miles
	1.5 pieces LW per channel width	7% increase	1.6 pieces LW per channel width
Alder 1A	Partial barrier at RM 1.7		Access to 3.8 river miles
	63% of full riparian function	59% improvement	100% of full riparian function
	1.5 pieces LW per channel width	100% increase	3 pieces LW per channel width
Alder 2	63% of full riparian function	59% improvement	100% of full riparian function
	1.5 pieces LW per channel width	100% increase	3 pieces LW per channel width
Cedar 1	Partial barrier at ~ RM 0.5		Access to ~ 11.5 river miles
	7 mg/l of dissolved oxygen	14% increase	8 mg/l of dissolved oxygen
	EDT fish pathogen score of 2	20% improvement	EDT fish pathogen score of 1.6
	EDT minimum water temperature score of 1	20% decrease in the score	EDT minimum water temperature score of 0.8
	EDT score of 2 in the maximum water temperature score	20% decrease in the score	EDT score of 1.6 in the maximum water temperature score
	EDT temperature moderation by groundwater score of 3	33% improvement in the score	EDT temperature moderation by groundwater score of 2
Cedar 2	7 mg/l of dissolved oxygen	14% increase[c]	8 mg/l of dissolved oxygen
	EDT score of 2 in fish pathogen score	20% improvement in the score[c]	EDT score of 1.6 in fish pathogen score
	15% of total is off-channel habitat	75% increase[b]	26% of total is off-channel habitat
	63% of full riparian function	19% improvement[b]	75% of full riparian function
	EDT minimum water temperature score of 1	20% decrease in the score[c]	EDT minimum water temperature score of 0.8
	EDT maximum water temperature score of 2	20% decrease in the score[c]	EDT maximum water temperature score of 1.6
	EDT temperature moderation by groundwater score of 3	33% improvement in the score[b]	EDT temperature moderation by groundwater score of 2
	1.5 pieces LW per channel width	167% increase[c]	4 pieces LW per channel width
Cedar 3	7 mg/l of dissolved oxygen	14% increase[c]	8 mg/l of dissolved oxygen
	EDT fish pathogen score of 2	20% improvement[c]	EDT fish pathogen score of 1.6
	6% of total is beaver pond habitat	39% increase[c]	8% of total is beaver pond habitat
	15% of total is off-channel habitat	45% increase[c]	22% of total is off-channel habitat
	21% of total is pool habitat	25% increase[c]	26% of total is pool habitat
	63% of full riparian function	19% improvement [c]	75% of full riparian function
	EDT minimum water temperature score of 1	20% decrease in the score[c]	EDT minimum water temperature score of 0.8
	EDT maximum water temperature score of 2	20% decrease in the score[c]	EDT maximum water temperature score of 1.6
	EDT temperature moderation by groundwater score of 3	33% improvement in the score[c]	EDT temperature moderation by groundwater score of 2
	1.5 pieces LW per channel width	100% increase[c]	3 pieces LW per channel width

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Table E-14. Habitat Benefits for Winter Steelhead in the Middle Sandy River Watershed by Reach, continued

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Sandy 3	83% of full riparian function	5% improvement	87% of full riparian function
	EDT score of 3 in the maximum water temperature score	1% decrease in the score	EDT score of 2.97 in the maximum water temperature score
	2.0 pieces LW per channel width	31% increase	2.6 pieces LW per channel width
Sandy 7	25.0 carcasses per stream mile	70% increase[c, d]	42.5 carcasses per stream mile
	EDT score of 2 in the maximum water temperature score	2% decrease in the score	EDT score of 1.97 in the maximum water temperature score

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Alder 1A riparian function, the current condition of 63% will be improved by 59% to give 0.63+(0.63*0.59)=1.0.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-15. Habitat Benefits for Winter Steelhead in the Upper Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Sandy 8	63% of full riparian function	14% improvement	72% of full riparian function
	113 carcasses per stream mile	31% increase[c,d]	148 carcasses per stream mile
	EDT score of 2 in the maximum water temperature score	3% decrease in the score	EDT score of 1.95 in the maximum water temperature score
	2.0 pieces LW per channel width	34% increase	2.7 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Sandy 8 riparian function, the current condition of 63% will be improved by 14% to give 0.63+(0.63*0.14)=0.72.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-16. Habitat Benefits for Winter Steelhead in the Salmon River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Boulder 0	24% fine sediments by surface area	5% decrease	22.8% fine sediments by surface area
	EDT maximum water temperature score of 1.5	27% decrease in the score	EDT maximum water temperature score of 1.1
	0.7 pieces LW per channel width	315% increase	2.8 pieces LW per channel width
Boulder 1	83% of full riparian function	20% improvement	100% of full riparian function
	EDT maximum water temperature score of 1.5	13% decrease in the score	EDT maximum water temperature score of 1.3
	1.5 pieces LW per channel width	133% increase	3.5 pieces LW per channel width
Salmon 1	3% of total is off-channel habitat	66% increase	4% of total is off-channel habitat
	3% of total is small-cobble riffles	54% decrease	5% of total is small-cobble riffles
	75% of full riparian function	8% improvement	81% of full riparian function
	200 carcasses per stream mile	50% increase[c,d]	300 carcasses per stream mile
	EDT maximum water temperature score of 3	21% decrease in the score	EDT maximum water temperature score of 2.36
	2.0 pieces LW per channel width	62% increase	3.2 pieces LW per channel width
Salmon 2	14.0 cm is average depth of bed scour	3% reduction	13.6 cm is average depth of bed scour
	25% artificial confinement	12% reduction	22% artificial confinement
	3% of total is off-channel habitat	90% increase	5% of total is off-channel habitat
	50% of full riparian function	33% improvement	67% of full riparian function
	EDT maximum water temperature score of 2	2% decrease in the score	EDT maximum water temperature score of 1.97
	2.0 pieces LW per channel width	67% increase	3.3 pieces LW per channel width
Salmon 3	2 pieces LW per channel width	90% increase in the amount of LW	3.8 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Boulder 0 fine sediment, the current condition of 24% will be reduced by 5% to give 0.24-(0.24*0.05)=0.228

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-17. Habitat Benefits for Winter Steelhead in the Zigzag River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Zigzag 1A	40% artificial confinement	38% reduction	25% artificial confinement
	EDT harassment score of 1.5	14% improvement in the score	EDT harassment score of 1.29
	20% of total habitat is large-cobble riffles	20% decrease	15% of total habitat is large-cobble riffles
	55% of total habitat is small-cobble riffles	4% increase	57% of total habitat is small-cobble riffles
	15% of total habitat is pools	15% increase	17% of total habitat is pools
	3% of total habitat is pool-tails	27% increase	4% of total habitat is pool-tails
	63% of full riparian function	7% improvement	68% of full riparian function
	113 carcasses per stream mile	167% increase[c,d]	300 carcasses per stream mile
	0.7 pieces LW per channel width	323% increase	2.8 pieces LW per channel width
Zigzag 1B	113 carcasses per stream mile	167% increase[c]	300 carcasses per stream mile
Zigzag 1C	13 carcasses per stream mile	100% increase[c,d]	25 carcasses per stream mile

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Zigzag 1A artificial confinement, the current condition of 40% will be reduced by 38% to give 0.40-(0.40*0.38)=0.25.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Habitat Benefits for Coho

Table E-18. Habitat Benefits for Coho in the Lower Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Beaver 1A	63% of full riparian function	3% improvement	65% of full riparian function
	0.7 pieces LW per channel width	21% increase	0.8 pieces LW per channel width
Gordon 1A	24% surface area of gravel patches is fine sediment	25% decrease	18% surface area of gravel patches is fine sediment
	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	30% of total habitat is large-cobble riffles	17% decrease	25% of total habitat is large-cobble riffles
	14% of total is pool habitat	115% increase	30% of total is pool habitat
	3% of total habitat is pool-tail habitat	46% increase	5% of total habitat is pool-tail habitat
	52% of total habitat is small-cobble riffles	33% decrease	35% of total habitat is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Gordon 1B	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	6% of total is pool habitat	212% increase	20% of total is pool habitat
	1% of total is pool-tail habitat	326% increase	5% of total is pool-tail habitat
	58% of total is small-cobble riffles	40% decrease	35% of total is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Sandy 1	25% artificial confinement	20% reduction	20% artificial confinement
	63% of full riparian function	19% improvement	75% of full riparian function
	6.5 pieces LW per channel width	35% increase	8.8 pieces LW per channel width
Sandy 2	38% of full riparian function	69% improvement	64% of full riparian function
	EDT maximum water temperature score of 3	3% decrease in the score	EDT maximum water temperature score of 2.9
	6.5 pieces LW per channel width	121% increase	14.4 pieces LW per channel width
Trout 1A	1.5 pieces LW per channel width	7% increase	1.6 pieces LW per channel width
Trout 2A	1.5 pieces LW per channel width	13% increase	1.7 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Beaver 1A riparian function, the current condition of 63% will be improved by 3% to give 0.63+(0.63*0.03)=0.65.

Table E-19. Habitat Benefits for Coho in the Middle Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Alder 1	Partial barrier at RM 0.1		Access to 1.6 river miles
	1.5 pieces LW per channel width	7% increase	1.6 pieces LW per channel width
Alder 1A	Partial barrier at RM 1.7		Access to 3.8 river miles
	63% of full riparian function	59% improvement	100% of full riparian function
	1.5 pieces LW per channel width	100% increase	3 pieces LW per channel width
Alder 2	63% of full riparian function	59% improvement	100% of full riparian function
	1.5 pieces LW per channel width	100% increase	3 pieces LW per channel width
Cedar 1	Partial barrier at ~ RM 0.5		Access to ~ 11.5 river miles
	7 mg/l of dissolved oxygen	14% increase	8 mg/l of dissolved oxygen
	EDT fish pathogen score of 2	20% improvement	EDT fish pathogen score of 1.6
	EDT minimum water temperature score of 1	20% decrease in the score	EDT minimum water temperature score of 0.8
	EDT score of 2 in the maximum water temperature score	20% decrease in the score	EDT score of 1.6 in the maximum water temperature score
	EDT temperature moderation by groundwater score of 3	33% improvement in the score	EDT temperature moderation by groundwater score of 2
Cedar 2	7 mg/l of dissolved oxygen	14% increase[c]	8 mg/l of dissolved oxygen
	EDT score of 2 in fish pathogen score	20% improvement in the score[c]	EDT score of 1.6 in fish pathogen score
	15% of total is off-channel habitat	75% increase[c]	26% of total is off-channel habitat
	63% of full riparian function	19% improvement[c]	75% of full riparian function
	EDT minimum water temperature score of 1	20% decrease in the score[c]	EDT minimum water temperature score of 0.8
	EDT maximum water temperature score of 2	20% decrease in the score[c]	EDT maximum water temperature score of 1.6
	EDT temperature moderation by groundwater score of 3	33% improvement in the score[c]	EDT temperature moderation by groundwater score of 2
	1.5 pieces LW per channel width	167% increase[c]	4 pieces LW per channel width
Cedar 3	7 mg/l of dissolved oxygen	14% increase[c]	8 mg/l of dissolved oxygen
	EDT fish pathogen score of 2	20% improvement[c]	EDT fish pathogen score of 1.6
	6% of total is beaver pond habitat	39% increase[c]	8% of total is beaver pond habitat
	15% of total is off-channel habitat	45% increase[c]	22% of total is off-channel habitat
	21% of total is pool habitat	25% increase[c]	26% of total is pool habitat
	63% of full riparian function	19% improvement[c]	75% of full riparian function
	EDT minimum water temperature score of 1	20% decrease in the score[c]	EDT minimum water temperature score of 0.8
	EDT maximum water temperature score of 2	20% decrease in the score[c]	EDT maximum water temperature score of 1.6
	EDT temperature moderation by groundwater score of 3	33% improvement in the score[c]	EDT temperature moderation by groundwater score of 2
	1.5 pieces LW per channel width	100% increase[c]	3 pieces LW per channel width

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Table E-19. Habitat Benefits for Coho in the Middle Sandy River Watershed by Reach, continued

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Sandy 3	83% of full riparian function	5% improvement	87% of full riparian function
	EDT score of 3 in the maximum water temperature score	1% decrease in the score	EDT score of 2.97 in the maximum water temperature score
	2.0 pieces LW per channel width	31% increase	2.6 pieces LW per channel width
Sandy 7	25.0 carcasses per stream mile	70% increase[c,d]	42.5 carcasses per stream mile
	EDT score of 2 in the maximum water temperature score	2% decrease in the score	EDT score of 1.97 in the maximum water temperature score

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Alder 1A riparian function, the current condition of 63% will be improved by 59% to give 0.63+(0.63*0.59)=1.0.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-20. Habitat Benefits for Coho in the Upper Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Sandy 8	63% of full riparian function	14% improvement	72% of full riparian function
	113 carcasses per stream mile	31% increase[c,d]	148 carcasses per stream mile
	EDT score of 2 in the maximum water temperature score	3% decrease in the score	EDT score of 1.95 in the maximum water temperature score
	2.0 pieces LW per channel width	34% increase	2.7 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Sandy 8 riparian function, the current condition of 63% will be improved by 14% to give 0.63+(0.63*0.14)=0.72.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-21. Habitat Benefits for Coho in the Salmon River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Boulder 0	24% fine sediments by surface area	5% decrease	22.8% fine sediments by surface area
	EDT maximum water temperature score of 1.5	27% decrease in the score	EDT maximum water temperature score of 1.1
	0.7 pieces LW per channel width	315% increase	2.8 pieces LW per channel width
Boulder 1	83% of full riparian function	20% improvement	100% of full riparian function
	EDT maximum water temperature score of 1.5	13% decrease in the score	EDT maximum water temperature score of 1.3
	1.5 pieces LW per channel width	133% increase	3.5 pieces LW per channel width
Salmon 1	3% of total is off-channel habitat	66% increase	4% of total is off-channel habitat
	3% of total is small-cobble riffles	54% decrease	5% of total is small-cobble riffles
	75% of full riparian function	8% improvement	81% of full riparian function
	200 carcasses per stream mile	50% increase[c,d]	300 carcasses per stream mile
	EDT maximum water temperature score of 3	21% decrease in the score	EDT maximum water temperature score of 2.36
	2.0 pieces LW per channel width	62% increase	3.2 pieces LW per channel width
Salmon 2	14.0 cm is average depth of bed scour	3% reduction	13.6 cm is average depth of bed scour
	25% artificial confinement	12% reduction	22% artificial confinement
	3% of total is off-channel habitat	90% increase	5% of total is off-channel habitat
	50% of full riparian function	33% improvement	67% of full riparian function
	EDT maximum water temperature score of 2	2% decrease in the score	EDT maximum water temperature score of 1.97
	2.0 pieces LW per channel width	67% increase	3.3 pieces LW per channel width
Salmon 3	2 pieces LW per channel width	90% increase in the amount of LW	3.8 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Boulder 0 fine sediments, the current condition of 24% will be reduced by 5% to give 0.24-(0.24*0.05)=0.228.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Literature Cited

Lestelle, L.C., L.E. Mobrand, and W.E. McConnaha. 2004. *Information Structure of Ecosystem Diagnosis and Treatment (EDT) and Habitat Rating Rules for Chinook Salmon, Coho Salmon, and Steelhead Trout.* Mobrand Biometrics, Inc.

Appendix F. Monitoring and Research Protocols

Introduction

Chapter 9 of the Habitat Conservation Plan (HCP) introduces the City of Portland's (City's) monitoring and research programs designed to document compliance and verify progress toward meeting the measurable objectives defined in that chapter. Protocols for effectiveness monitoring are provided in this appendix. Protocols for compliance monitoring are provided in Tables 9-1 and 9-2 in Chapter 9.

The City will also conduct a series of research measures. Protocols for these measures are also included in this appendix. Research in the Bull Run watershed will include spawning gravel availability, the degree of Chinook spawning gravel bed scour, adult Chinook counts, and concentrations of total dissolved gases (TDG). The City will also conduct research on juvenile salmonid outmigrants (JOMs) in conjunction with the Oregon Department of Fish and Wildlife (ODFW), U.S. Forest Service (USFS, Mt. Hood National Forest), Bureau of Land Management (BLM), and the Oregon Department of Environmental Quality (ODEQ) in the Sandy River Basin. The City's research is in addition to the compliance and effectiveness monitoring efforts of the HCP and it plays an important role in the City's adaptive management approach described Chapter 9.

Effectiveness Monitoring

Effectiveness monitoring protocols are described below for the in-channel measures that will be conducted in the Sandy River Basin. These measures include large wood (LW) placement/log jam creation, side-channel development, river mouth reestablishment, and floodplain reconnection.

Effectiveness Monitoring for Offsite In-channel Conservation Measures

This protocol describes sampling methods and assessment procedures for monitoring the effectiveness of the offsite, in-channel conservation measures in Chapter 7 of this HCP. Offsite measures occur outside of the Bull Run River but within the anadromous reaches of the Sandy River watershed or in the tributary basin of the Little Sandy River.[1] In-channel measures occur actively within the normal high-flow channel of the stream. In-channel measures do not include efforts to improve the riparian zone.

[1] The Little Sandy River is a tributary of the Bull Run River, but enters below Dam 2. Although the Little Sandy is within the Bull Run watershed, its in-channel measure functions as an offsite measure.

Measurable Habitat Objectives and Working Hypothesis

The offsite in-channel measures discussed in Chapter 7 are summarized by reach and general restoration category in Table F-1. The measures and their predicted effects on habitat attributes have been evaluated using the Ecosystem Diagnostic and Treatment (EDT) model (City of Portland and Mobrand Biometrics 2004). The anticipated benefits of these measures are summarized by reach and ranked by predicted net change in the attributes' respective metrics in Table F-2 on the next page. The net attribute changes in Table F-2 include only benefits expected to be derived from in-channel restoration projects.

Table F-1. Treated Reaches in Watersheds by Treatment Category

Watershed	Treated Reaches	Project Treatment Types
Lower Sandy River	Gordon 1A and 1B, Trout 1A, Sandy 1 and 2	LW placement/log jam creation
	Sandy 1	Side-channel development
	Sandy 1	River mouth reestablishment
Middle Sandy River	Cedar 2 and 3	LW placement/log jam creation
Bull Run River	Little Sandy 1	LW placement/log jam creation
Salmon River	Salmon 2, Boulder 0 and 1	LW placement/log jam creation
	Salmon 2	Floodplain reconnection/side channel development
Zigzag River	Zigzag 1A	LW placement/log jam creation, Floodplain reconnection/ side-channel development

The net changes predicted in Table F-2 represent measurable habitat objectives created for each individual reach. The monitoring objective is to document the effectiveness of the offsite in-channel measures at accomplishing the measurable habitat objectives. The City's working hypothesis for effectiveness monitoring of the offsite in-channel conservation measures is that at least 80 percent of the projected changes in the key habitat attributes (pre-project versus post-project conditions) will occur in each affected stream reach. The "80 percent of the projected changes" is not an EDT output, but it is a performance level that the City is committing to for this HCP. The City chose the 80 percent level, instead of a 100 percent level, because there will be a high degree of natural variation, year to year and site to site. The natural variation will be further compounded by the error associated with measuring habitat variables in the field. Given this high level of variation, it would not be possible to statistically detect a difference between a 100 percent change in a habitat variable and a much smaller change. The City chose 80 percent as a minimum performance standard. If that level of habitat response is not met, additional actions will occur, and the City will follow the adaptive management program described in Chapter 9.

Table F-2. Attributes and Measurable Habitat Objectives in Reaches Affected by In-channel Measures

	Measurable Habitat Objective (80% of Net Change in Metric)		
Attribute	**Metric**	**Net Change**	**Reach**
Large wood	Number of pieces per channel width	26%	Sandy 1
Artificial confinement	% length of bank artificially confined	-20%	Sandy 1
Large wood	Number of pieces per channel width	70%	Sandy 2
Large wood	Number of pieces per channel width	19%	Sandy 8
Large wood	Number of pieces per channel width	567%	Gordon 1A
Backwater pools	Percentage of reach (by surface area) that comprises backwater pools	Increase from 0% to 5%	Gordon 1A
Pool habitat	Percentage of reach (by surface area) that comprises pool habitat	115%	Gordon 1A
Pool-tail habitat	Percentage of reach (by surface area) that comprises pool tail-outs	46%	Gordon 1A
Small-cobble riffles	Percentage of reach (by surface area) that comprises small cobble riffles	-33%	Gordon 1A
Fine sediment	Percentage of gravel patches (by surface area) that is fine sediment	-25%	Gordon 1A
Large-cobble riffle	Percentage of reach (by surface area) that comprises large cobble riffles	-17%	Gordon 1A
Large wood	Number of pieces per channel width	567%	Gordon 1B
Pool habitat	Percentage of reach (by surface area) that comprises pool habitat	212%	Gordon 1B
Pool-tail habitat	Percentage of reach (by surface area) that comprises pool tail-outs	326%	Gordon 1B
Backwater pools	Percentage of reach (by surface area) that comprises backwater pools	Increase from 0% to 5%	Gordon 1B
Small-cobble riffles	Percentage of reach (by surface area) that comprises small cobble riffles	-40%	Gordon 1B
Large wood	Number of pieces per channel width	7%	Trout 1A
Large wood	Number of pieces per channel width	13%	Trout 2a
Large wood	Number of pieces per channel width	34%	Little Sandy 1
Large wood	Number of pieces per channel width	100%	Cedar 2
Large wood	Number of pieces per channel width	67%	Cedar 3
Beaver ponds	Percentage of reach (by surface area) that comprises beaver ponds	39%	Cedar 3
Pool habitat	Percentage of reach (by surface area) that comprises pool habitat	25%	Cedar 3

Table continued on next page.

Table F-2. Attributes and Measurable Habitat Objectives in Reaches Affected by In-channel Measures, continued

Attribute	Measurable Habitat Objective (80% of Net Change in Metric): Metric	Net Change	Reach
Large wood	Number of pieces per channel width	10%	Salmon 2
Artificial confinement	% length of bank artificially confined	-12%	Salmon 2
Large wood	Number of pieces per channel width	90%	Salmon 3
Large wood	Number of pieces per channel width	231%	Boulder 0
Large wood	Number of pieces per channel width	100%	Boulder 1
Large wood	Number of pieces per channel width	291%	Zigzag 1A
Artificial confinement	% length of bank artificially confined	-38%	Zigzag 1A
Large-cobble riffle	Percentage of reach (by surface area) that comprises large cobble riffles	-25%	Zigzag 1A
Small-cobble riffle	Percentage of reach (by surface area) that comprises small cobble riffles	4%	Zigzag 1A
Pools	Percentage of reach (by surface area) that comprises pools	27%	Zigzag 1A
Pool-tails	Percentage of reach (by surface area) that comprises pool-tails	15%	Zigzag 1A

Key Questions/Hypotheses. One key question will be answered by the offsite monitoring protocol:

Did the implementation of the restoration projects result in the changes to the monitored habitat attributes that were predicted by the EDT assessment?

- H_o: The mean of post-treatment values in treatment reaches will not be significantly less than the change from baseline values predicted by the EDT assessment.

In order to make this comparison, the baseline values in EDT will be updated by collecting two years of pre-treatment data on all the habitat attributes that are predicted to significantly change (summarized in Table F-2). If the baseline habitat conditions are the same or worse than those used to develop the measurable habitat objectives summarized in Table F-2, the City will proceed with the in-channel conservation measures as described in the HCP. If the current reach habitat conditions are found to be better than those originally rated in 2003, the City will follow the framework for adaptive response described in Section 9.4.3 of the HCP.

The comparison of the observed changes in monitored habitat attributes to measurable habitat objectives will be analyzed both numerically and statistically (using a 95 percent level of confidence). The numeric test will simply determine if the mean of post-treatment values is at least 80 percent of the target values. The measurable habitat objective for each offsite in-channel measure response variable was set at 80 percent of the projected change for the numeric comparison to account for the fact that each variable is expected to show a large degree of natural variation, year to year and site to site. This natural variation will be compounded by the error associated with measuring habitat attributes in the field. The statistical test will assign a level of confidence to each of the pre-treatment and post-treatment values and determine the power of the statistical test to detect significant shortfalls. Having a level of confidence associated with each EDT value will be helpful during the adaptive management process, if any post-treatment value should fall short of the measurable habitat objective. The numeric comparison will provide a back-up criterion, in case the statistical comparison does not have adequate power to detect significant shortfalls in the measurable habitat objectives.

Monitoring Design

The City has the following options to monitor the effects of its instream restoration efforts:

1. Compare each reach's post-treatment condition to its pre-treatment condition. This option requires collecting data over many pre-treatment and post-treatment years.
2. Compare the both the pre-treatment and post-treatment condition of each reach with those of a similar control reach. This also requires the collection of data over multiple years, but because a control reach will account for much of the variation in measurable habitat attributes caused by factors such as storms or other disturbances, a smaller number of years will be sufficient.

The City has selected the second monitoring option because the time and resources necessary to collect data over a large number of pre-treatment and post-treatment years would be prohibitive. The City will use a Before-After with Control-Impact (BACI) study design to monitor the effects of the HCP offsite, instream mitigation projects (Roni et al. 2005). Control reaches upstream of the treated reaches will be surveyed, in addition to the treated reaches (Table F-3). Control reaches will be entire upstream reaches delineated for EDT or one mile in length, whichever is less, to minimize survey effort, yet provide a representative length of stream. In cases in which a treated reach is very long (over five miles) and the treatment is restricted to the lower portion of the reach, the upstream portion of the same reach will serve as a control. This approach is used because the further upstream that a control reach is, the less representative it probably is of the habitat where treatment occurred. Given the hierarchical nature of stream networks, many treatment and control reaches are downstream of other reaches where the City will implement restoration projects. These upstream treatment reaches could influence downstream reaches by, for example, exporting large wood. Control reaches could be influenced in this way more than the respective treatment reach because they are, in every case, located upstream. This potential bias cannot be avoided but is likely to make the comparison more conservative. The City will remain cognizant of it when analyzing monitoring data. The City will use attribute values for the entire EDT reach (including control-reach segment) as the treatment reach values and just attribute values from the control-reach segment as the respective control-reach values.

Table F-3. Paired Treated and Control Reaches

HCP Years Implemented	Watershed	Treated Reaches	Control Reaches
1–5	Lower Sandy River	Trout 1A	Trout 3A
		Trout 2A	Trout 3A
		Gordon 1A	Gordon 2A
		Gordon 1B	Gordon 2A
	Bull Run River	Little Sandy 1	Little Sandy 2
	Salmon River	Boulder 0	Boulder 2
		Boulder 1	Boulder 2
6–10	Lower Sandy River	Sandy 1	Sandy 1
		Sandy 2	Sandy 2
	Middle Sandy River	Cedar 2	Cedar 4
		Cedar 3	Cedar 4
11–15	Salmon River	Salmon 2	Salmon 2
	Zigzag River	Zigzag 1A	Zigzag 1B

Sampling Scheme. Habitat attributes in both treatment and control reaches will be monitored using the ODFW Aquatic Inventories Project (AIP) stream habitat survey protocol (Moore et al. 2002). The AIP survey protocol is an extensive inventory of stream channel, riparian vegetation, and aquatic habitat conditions following a stratified-systematic sampling design

The standard AIP protocol involves two main sources of error. The City will adjust the protocol to reduce these sources of error. The first source of error stems from the strategy of estimating habitat dimensions throughout a reach and then using a subset of measurements to correct the estimates. These corrections are associated with a range of variability, which decreases confidence in the final result. To maximize the statistical power of the monitoring data analysis, given the small sample size of pre-treatment data, all habitat unit dimensions will be measured. The second source of error is measurement error, which can accumulate over the length of a reach. The City will monument survey reaches at specific intervals to allow for standardization of lengths between years.

In addition to the standard AIP in-channel data, surveys will include a measurement of the length of each bank that is artificially constrained. Other riparian information will not be collected, except for recording observations that directly pertain to interpreting instream conditions. Collecting extensive riparian data would dramatically increase survey effort without contributing to the evaluation of the in-channel restoration efforts. The AIP protocols will also be modified by the addition of a habitat-unit-scale visual estimate of off-channel habitat, other than side channels, for each unit. Off-channel habitat will be defined as the estimated surface area of individual alcove habitats, the portion of certain tributaries that flow over the main channel's floodplain and provide access to fish from the main channel, or ponds adjacent to the channel but connected to it only during high-water events. The surface area of these habitats will not be included in the total surface area of adjacent habitat units. During analysis, these data will be combined with data on side channels to estimate the percentage of each reach's total habitat that consists of off-channel habitat.

Scale. The measurable habitat objectives (Table F-2) are reach-scale objectives. The AIP protocols collect data at both the habitat-unit and reach scales, but they all are used to derive reach-scale assessments of habitat condition. Reaches vary in length, so all attribute values will be normalized by either channel length or surface area.

Data that will be collected. The habitat attributes used by EDT to evaluate restoration alternatives are derived from the data-types summarized below. All are information collected during stream surveys. However, not all attributes will be used to evaluate the effectiveness of the offsite in-channel measures.

- Reach-scale data
    - Active channel (Bankfull)[2] width (feet)
    - Gradient (%)
    - Total surface area of off-channel habitat (estimated visually in square feet)
- Habitat unit-scale data
    - Habitat type (pool, backwater pool, beaver pond, glide, small cobble riffle, large cobble riffle)
    - Average length (feet)
    - Average width (feet)
    - Amount of pool tail-out habitat (Data collected in pools only, percentage of total surface area that is at the down-stream end of the pool and flowing with velocities comparable to those of neighboring glides and riffles)
    - Confinement – Natural (categorical: confined, moderately confined, unconfined)
    - Confinement – Hydrological modifications (% of both banks)
    - In-channel wood (# pieces greater than 1 foot diameter and greater than 7 feet long in active channel of habitat unit)
    - Fine sediment in spawning habitat types (% surface area of gravel patches in small cobble riffles; pool tail-outs, glides)
    - Embeddedness in spawning habitat types (% of the vertical dimension of surface cobbles and large gravel that is buried in fine sediment in gravel patches in small cobble riffles; pool tail-outs, glides)

These data will allow the City to evaluate how well it has met most of the measurable habitat objectives summarized in Table F-2. The percentage of fine sediment in spawning gravels may show too much within-reach variability to allow the detection of the anticipated change.

[2] The active channel, or bankfull channel, is the portion of the channel where flows occur often enough to prevent the establishment of vegetation, generally corresponding to a break in the slope of the bank.

Replication/Duration. Most habitat attributes are naturally variable from year to year. For example, there may not be formation of pools expected to result from the addition of wood during the first winter if high flows do not occur. In other years, high flows might fill in some pools and create new ones elsewhere. For this reason, Before (pre-treatment) and After (post-treatment) data will be replicated across time. Pre-treatment data for each reach will be collected for two years (n_{before}=2). This replication provides a minimum estimate of annual variation in habitat features when comparing pre-treatment and post-treatment data in treatment and control streams. Monitoring will continue once every three years *after* treatment for the first 15 years for a total of 5 post-treatment sampling surveys (n_{after}=5).

The monitoring schedule is tied implicitly to the HCP implementation schedule, as shown in Table F-4. In-channel restoration projects are anticipated to provide rapid changes in stream habitat conditions and, hence, relatively immediate benefits to fish productivity. The City has assumed the life of each in-channel project to be approximately 15 years. Monitoring results will be summarized and discussed at the first monitoring check-in meeting with NMFS following 15 years of data collection. A monitoring program for assessment in subsequent years will be reviewed and approved during the Year 15 check-in meeting.

Table F-4. Schedule for Offsite Mitigation Effectiveness Monitoring

				HCP Plan Year																						
Years	**Reach**	**Total Length**	**Treated Length**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
	Trout 1A	0.5	0.2	B	B	A			A			A			A			A								
	Trout 2a	0.3	0.3	B	B	A			A			A			A			A								
	Trout 3a	0.5	-	C	C	C			C			C			C			C								
	Gordon 1A	1.6	1.8	B	B	A			A			A			A			A								
1–5	Gordon 1B	2.4	2.2	B	B	A			A			A			A			A								
	Gordon 2a	3.2	-	C	C	C			C			C			C			C								
	Boulder 0	0.3	0.3	B	B	A			A			A			A			A								
	Boulder 1	0.6	0.6	B	B	A			A			A			A			A								
	Boulder 2	3.7	-	C	C	C			C			C			C			C								
Subtotal																										
	Sandy 1	5.4	1.0				B	B	A			A			A			A			A					
	Sandy 1	5.4	1.0				C	C	C			C			C			C			C					
	Sandy 2	12.4	1.0				B	B	A			A			A			A			A					
	Sandy 2	12.4	1.0				C	C	C			C			C			C			C					
6–10	Little Sandy 1	1.8	1.8				B	B	A			A			A			A			A					
	Little Sandy 2	1.0	-				C	C	C			C			C			C			C					
	Cedar 2	3.4	3.5				B	B	A			A			A			A			A					
	Cedar 3	5.3	5.3				B	B	A			A			A			A			A					
	Cedar 4	4.5	-				C	C	C			C			C			C			C					
Subtotal																										
	Salmon 2	6.2	0.3									B	B	A			A			A			A			A
	Salmon 2	6.2	0.3									C	C	C			C			C			C			C
	Sandy 8[b]	5.6	-									B	B	A			A			A			A			A
	Sandy 9	-	-									C	C	C			C			C			C			C
11–15	Zigzag 1A	2.2	1.1									B	B	A			A			A			A			A
	Zigzag 1A	2.2	1.1									C	C	C			C			C			C			C
	Zigzag 1B	5.1	2.4									B	B	A			A			A			A			A
	Zigzag 1B	5.1	2.4									C	C	C			C			C			C			C
Subtotal																										
Total																										
Evaluation																					M/R			

[a]B= Before (Pre-Treatment) surveys, A=After (Post-Treatment) Surveys, C=Control surveys (survey reaches are shaded in the table), M/R=Meeting of the Basin Partners/Report
[b]Sandy 8 is expected to receive significant benefits from restoration work done in Zigzag 1A and 1.

Analysis

Data Storage. Monitoring data collected during the HCP will be maintained by the City in a Microsoft® Access database. Summary data will be added to the Sandy River EDT database. It will be made available to NMFS for review at any time and will be extensively discussed during the HCP Year 20 check-in meeting of the City with NMFS. Following quality assurance/quality control procedures, and review and approval by the City and NMFS, the data will be made available to the StreamNet Library (through the Columbia River Inter-Tribal Fish Commission [CRITFC] technical reports), ODFW AIP (http://oregonstate.edu/Dept/ODFW/freshwater/inventory/index.htm), and the USFS Natural Resource Information System (NRIS) Water module databases. Each of these databases was consulted extensively in the Sandy River Basin EDT analysis. Appropriate treatment- and control-reach data that are already in these databases will be used to bolster the sample size of the pre-treatment habitat attributes. Pre-existing data will not be used if the habitat in the respective streams has since been modified by restoration activities other than the planned HCP offsite in-channel measures.

Hypothesis Testing. Both the numeric and statistical evaluation of the hypotheses for the monitoring plan key question suggest a fundamental comparison between pre-treatment and post-treatment data on a reach-by-reach, attribute-by-attribute basis. Control reaches will be employed to subtract out variation due to large-scale effects outside of the City's control. An example of how this would occur is given below (T=Treatment reach value, C=Control reach value):

$$\left.\begin{array}{l} T_{before1}-C_{before1} \\ T_{before2}-C_{before2} \end{array}\right\} \ \textbf{mean} \quad \text{vs.} \quad \textbf{mean} \ \left\{\begin{array}{l} T_{after1}-C_{after1} \\ T_{after2}-C_{after2} \\ T_{after3}-C_{after3} \\ T_{after4}-C_{after4} \\ T_{after5}-C_{after5} \end{array}\right.$$

The numeric comparison of the means of pre-treatment and post-treatment data will determine whether or not the post-treatment mean is equal to or greater than 80 percent of the measurable habitat objective. For statistical comparisons, t-tests will be performed on the differences between treatment reach and control reach habitat attribute values, with a 95 percent level of confidence.

Adaptive Management. If data indicate that the effectiveness monitoring protocol hypotheses should be rejected and the new EDT results do not indicate that the predicted changes to freshwater productivity would be at least as much as originally described for the City's offsite in-channel conservation measures, the City will follow the adaptive management process described in Chapter 9 of the HCP.

Research Program

The City will conduct research on several factors in the Bull Run watershed: spawning gravel placement, the degree of Chinook spawning gravel bed scour, and concentrations of TDG. In addition, the City will work with ODFW, USFS (Mt. Hood National Forest), BLM, and ODEQ to measure JOMs in the Sandy River Basin. The results of the City's research will be evaluated with monitoring results to determine the City's adaptive management response over time.

Research in the Bull Run Watershed

Lower Bull Run River Spawning Gravel Research Protocol

The availability of appropriate gravel patches can limit the productivity of salmonid populations within a given stream. The dams on the Bull Run River block the downstream movement of stream-bed substrates. These obstructions have contributed over time to a net loss of spawning gravel patches in the lower Bull Run River, as gravel is washed away and then not replaced.

The availability of spawning gravel in the lower Bull Run River was estimated in 1997, 1999, and 2001 (R2 Resource Consultants 1998, Beak and CH2M Hill 2001). The most recent survey estimated that there are approximately 1,082 square feet of spawning gravel available to steelhead and 1,352 square feet available to Chinook salmon.

The City's HCP proposes adding adequately sized gravel annually to the lower Bull Run River to benefit spawning salmonids. This appendix describes the methods and protocols for monitoring the effectiveness of this effort to increase the surface area of spawning gravel in the lower Bull Run River.

Measurable Habitat Objectives

The City identified a measurable habitat objective for the spawning gravel placement conservation measure (see HCP Chapters 7 and 9). The City will supply spawning gravel in amounts equivalent to or exceeding natural supply rates. The City will augment spawning gravel in the lower Bull Run River with a total of 1,200 cubic yards of gravel annually for the first 5 years of the HCP implementation. This roughly doubles the estimated natural recruitment rate of gravel, in the absence of reservoirs (calculations and estimates summarized in CH2M Hill 2003) and is intended to accelerate the accumulation of gravel in the lower Bull Run River. After five years, the rate of gravel supplementation by the City would be decreased to 600 cubic yards annually for the remainder of the HCP, the estimated natural recruitment rate in the absence of upstream reservoirs. The City, however, cannot predict how the gravel will be distributed or how quickly it will be moved downstream. There is no information on the areal extent of spawning gravel in the lower Bull Run prior to the construction of the Bull Run dams, beginning in 1929.

Research Objective

The objective of the Bull Run River spawning gravel research is to measure the surface area of patches of gravel suitable for spawning steelhead and Chinook salmon in an index reach of the lower Bull Run River. Separate estimates will be generated for steelhead and Chinook salmon. The City will quantify both the surface area of all patches with suitable substrate size ranges and the surface area of the subset of the patches that would be effective for spawning. Effective spawning gravel patches are patches that experience adequate depth and flow throughout the egg and alevin incubation period.

Key Questions/Hypotheses

The key questions (and related hypotheses) to be answered by the Bull Run River spawning gravel research are the following:

Question 1: What is the summed surface area of gravel patches suitable for steelhead and Chinook spawning in the lower Bull Run River and has it significantly increased from pre-supplementation values?

- H_o: The summed surface area of spawning gravel patches in each post-supplementation year will not be significantly greater than the mean of pre-supplementation years (one-sample t-test, α=0.05).

The pre-supplementation years that will be used for the analysis are 1997, 1999, and 2001. The City may also do additional spawning gravel surveys prior to the start of the HCP. If those surveys are completed, the data from those surveys will also be used as pre-supplementation years for the analysis.

Question 2: What is the effective spawning area of each reach (see below under *Research Design* for a definition of effective spawning area) at various combinations of flows and at the flows actually observed during steelhead incubation in the lower Bull Run River?

- H_o: The summed effective spawning area at various flow combinations in each post-supplementation year will not be significantly greater than the mean of pre-supplementation years (one-sample t-test, α =0.05).

The pre-supplementation years that will be used for the analysis are 1997, 1999, and 2001. The City may also do additional spawning gravel surveys prior to the start of the HCP. If those surveys are completed, the data from those surveys will also be used as pre-supplementation years for the analysis.

Question 3: What is the trend in the summed surface area of spawning gravel patches and the effective spawning area for each reach?

- H_o: The summed surface area of spawning gravel patches in post-supplementation years will not show a significant increase over time (α=0.05).
- H_o: The summed surface area of effective spawning gravel patches at various flow combinations in post-supplementation years will not show a significant increase over time (α=0.05).

Research Design

The design of the lower Bull Run spawning gravel research will involve the use of surveys of spawning gravel surface area to create a snapshot of the distribution of spawning gravel at a particular point in time. Previously developed relationships between stage and discharge in each reach will then be used to estimate the amount of spawning gravel that will have suitable depth and velocities for spawning and egg and alevin incubation at various flows for steelhead and spring and fall Chinook salmon.

The amount of steelhead spawning gravel will be estimated for the following flows:

- **1,405 cubic feet per second (cfs):** 10 percent average exceedence flow for March, April, and May (peak steelhead spawning months)
- **614 cfs:** 50 percent average exceedence flow for March, April, and May
- **120 cfs:** The lowest allowed flow during March, April, and May under the HCP measure for minimum flows (actual flows may be higher)

The amount of spring Chinook spawning gravel will be estimated for the following flows:

- **358 cfs:** 10 percent average exceedence flow for September and October (the peak spring Chinook spawning months)
- **77 cfs :** 50 percent average exceedence flow for September and October
- **30 cfs**: The lowest allowed flow during September and October under the HCP measure for minimum flows (actual flows may be higher)

The amount of fall Chinook spawning gravel will be estimated for the following flows:

- **1,480 cfs:** 10 percent average exceedence flow for October and November (the peak fall Chinook spawning months)
- **77 cfs :** 50 percent average exceedence flow for October and November
- **30 cfs**: The lowest allowed flow during October and November under the HCP measure for minimum flows (actual flows may be higher)

Calculating the amount of spawning gravel at the 10 percent and 50 percent exceedence flows, as well as the minimum allowable flow for each species' peak spawning period, allows for comparisons in the amount of spawning gravel across flows and across years. The amount of gravel wetted at the minimum allowable flow represents the minimum amount of gravel that would be available to each species. The amount of gravel wetted at the 10 percent and 50 percent exceedence flows indicates how far up the margins of the channel gravel accumulates and how much gravel remains available for spawning. This combined information will be used to evaluate the effectiveness of the HCP spawning gravel placement at increasing the amount of spawning gravel for steelhead and spring and fall Chinook.

The suitability of gravel patches in the lower Bull Run River for both spawning and incubation will be determined for each combination of flows above and for the actual flow regime experienced during steelhead and Chinook spawning and incubation in the year of the survey[3]. The area of gravel that meets depth and water velocity criteria for both spawning and incubation (Table F-5) during the respective period will be summed to determine the "effective spawning area" of each reach (R2 Resource Consultants 1998).

Table F-5. Minimum Gravel Depth and Water Velocity for Spawning and Incubation Periods for Steelhead and Chinook

	Steelhead	Chinook	Minimum Depth	Minimum Water Velocity
Spawning	March–May	September–November	0.6 feet	0.7 ft/sec
Incubation	March–July	September–April	0.1 feet	0.1 ft/sec

Source: R2 Resource Consultants 1998

Spatial Scale. Surveys will be used to determine the amount and quality of spawning gravel at various flows within the lower Bull Run River from the mouth to the Reservoir 2 spillway plunge pool. Results will be applicable only to the lower Bull Run River and have a reach-scale resolution.

Replication/Duration. Surveys will be conducted once per year in the late spring/early summer or early fall in conjunction with adult Chinook surveys. The surveys will occur after high flows associated with winter and spring storms have ceased, and spawning gravel patches have stabilized representing the amount available to steelhead and later to Chinook spawners for that year. There will be no spatial replication; the entire channel will be surveyed.

One survey will be conducted each year, from HCP Years 2 through 6, while increased gravel supplementation occurs. This represents the period of time when gravel is expected to accumulate most rapidly in the lower Bull Run River.

After gravel supplementation is reduced in Year 6 of the HCP, gravel surveys will continue once per year for an additional five years, from HCP Years 7 through 11. During this phase, gravel supplementation is primarily intended to maintain gravel deposits in the lower Bull Run River and surveys are designed to allow for an analysis powerful enough to detect negative trends in the surface area of spawning gravel.

Provided that gravel supplementation at maintenance levels does not result in a rapid negative trend during HCP Years 7 through 11, the frequency of gravel surveys will be reduced to once every five years for the duration of the HCP.

Variables. The following variables will be measured for each gravel patch:

- <u>Longitudinal Location</u>. Location relative to the beginning of the reach, measured with a hand-held global positioning system (GPS) device

[3] The high flows that recruit and redistribute gravel are expected to occur mostly after the Chinook and before the steelhead peak spawning months. Gravel surveys conducted during the late spring to early fall will therefore be most representative of the levels steelhead encountered the previous spring and what Chinook will encounter the following fall.

- Lateral Location. Location within the channel. Either in the center of the channel, in the channel margin, and above the channel margin (outside the wetted area but within the active channel[4])
- Retention Feature. Feature that acts on current to allow gravel deposition: pool-tail, boulder, bedrock, large wood, and/or slow margins
- Patch size. Surface area of patch (ft^2), calculated as total length multiplied by average width
- Depth or Elevation. For submerged patches, depth of the center of the patch below the water surface. For gravel patches above the water surface, elevation of the center of the patch above the water surface
- Velocity. The average velocity (ft/sec) at six-tenths depth from the surface over the upstream end of the gravel patch
- Embeddedness. The visually estimated percentage of the vertical dimension of surface substrates between 1.8 inches and 4 inches intermediate axis (roughly golf-ball size to softball size) that is surrounded by silt and sand. Average of 10 particles per patch of varying sizes. The percentage of total embeddedness will be calculated as

  $$\%\text{Total Embedded}=([(\%\text{Embedded}_{\text{large particles}}/100)*(100-\%\text{ fines})]+[\%\text{ fines}])/100.$$

  (Embeddedness procedures are reviewed in Sylte and Fischenich 2002).
- Percentage of Fines. Estimated surface area of patch covered by silt and sand (not a thin film over other obvious surface substrates)
- Dominant and Subdominant Substrate Size. Substrate size categories were chosen to correspond to various size thresholds used in previous surveys and gravel scour studies in the Bull Run River.
  - Silt and Sand: >0.1 inch
  - Small Gravel: 0.1 to 0.4 inch
  - Medium Gravel: 0.4 to 1.8 inches
  - Large Gravel: 1.8 to 4.0 inches
  - Small Cobble[5]: 4.0-6.0 inches

Sampling Scheme. Methods and protocols used to survey spawning gravel patches will closely follow those used in previous years (Beak and CH2M Hill 2001).

[4] The active channel, or bankfull channel, is the portion of the channel where flows occur often enough to prevent the establishment of vegetation, generally corresponding to a break in the slope of the bank.

[5] The size range of small cobble used here differs slightly from that used to define small cobble riffles for EDT, which considers small cobble to be from 2.9 to 5.0 inches. The range used here corresponds to the size of substrate that can be used by spawning Chinook salmon, but not by steelhead.

The lower Bull Run River will be divided into the following survey reaches:

- Reach 1: The confluence of the Bull Run River with the Sandy River to the bottom of the large pool above the Bull Run Portland General Electric (PGE) Powerhouse at RM 1.5
- Reach 2: The bottom of the large pool above the Bull Run PGE Powerhouse to Bowman's Bridge (RM 2.3)
- Reach 3: Bowman's Bridge (RM 2.3) to the confluence of the Little Sandy River (RM 2.8)
- Reach 4: The Little Sandy River Confluence (RM 2.8) to the top of the pool at Larson's Bridge (RM 3.7)
- Reach 5: Larson's Bridge (RM 3.7) to the Road 14 bridge (RM 4.8)
- Reach 6: The Road 14 bridge (RM 4.8) to the Reservoir 2 spillway plunge pool (RM 5.8)

These reach breaks were chosen to be compatible with the reaches used in 1997 and 2001 (R2 Resource Consultants 1997, Beak and CH2M Hill 2001) as well as those used in 1999 (Beak 2000a). They will be surveyed in an upstream direction.

The timing of surveys will be coordinated with operations at the City's Headworks facility and the PGE powerhouse. Flows will be reduced in the lower Bull Run River to less than 150 cfs for the duration of the survey, to allow for safe navigation by field crews and maximize the comparability of the resulting data to that of previous surveys.

Patches of gravel suitable for spawning steelhead and/or Chinook will be identified along the length of each reach. Patches of spawning gravel will be defined as being equal to or greater than 9 square feet, lying within the active channel and composed of substrates between 0.1 and 6.0 inches in diameter along their intermediate axis for Chinook, and between 0.1 and 4.0 inches in diameter for steelhead.

The depth and water velocity at each gravel patch at various flow levels will be determined as described in R2 Resource Consultants (1998), using stage-discharge relationships established for each reach. The amount of effective spawning gravel for each combination of flows will be calculated as described above. The amount of effective spawning gravel under the actual observed flow regime will be determined using flow data from the U.S. Geological Survey (USGS) Gauge No. 14140000.

Analysis

Data Storage. Data will be stored in a Microsoft® Access database managed by the City of Portland Water Bureau.

Hypothesis Testing. The hypotheses relating each year's measured surface area of gravel to the mean of pre-gravel supplementation years will be evaluated using one-tailed, one-sample t-tests (α=0.05). The power of each test will also be calculated.

The significance and direction of the trend in each category of gravel surface area over time will be evaluated using linear regression (α=0.05). The power of each regression will also be calculated.

Adaptive Management

In HCP Years 6 and 12, the City will summarize the effectiveness of the Bull Run spawning gravel placements. If spawning gravel placements are not successful, as defined through hypothesis testing, the City will meet with NMFS to determine options.

Chinook Spawning Gravel Scour Research

The lower Bull Run River experiences high flows during the late fall and winter months, when the Bull Run reservoirs are full and natural high flows exceed the withdrawals of water by the City's facilities. These flows can reach levels that are capable of mobilizing streambed substrates and therefore are a potential cause of mortality to salmonid eggs and alevins residing in the streambed. Flows of 600 cfs and greater—high enough to mobilize gravels of the size used by spawning Chinook salmon—are estimated to occur in the lower Bull Run River every one to one-and-a-half years (Carlson 2003). The Services identified the scouring of Chinook redds to be of particular concern in the lower Bull Run River.

This HCP defines measures to benefit spawning salmon, such as the maintenance of minimum flows in the lower river and the addition of gravel adequately sized for use by spawning salmon. These efforts can both affect and be affected by the scouring of spawning gravels. This appendix describes sampling methods and protocols for monitoring the effects of high flows on the stability of Chinook salmon redd gravels in the lower Bull Run River.

Research Objectives

The objective of this research effort is to measure the effects of high flows on bed elevation and scour depth for a number of sites used by spawning Chinook salmon.

Key Questions/Hypotheses

The key questions (and related hypotheses) to be answered by this monitoring protocol are:

<u>Question 1:</u> What is the mean change in bed elevation each year and its associated variance at the locations of Chinook salmon redds in the lower Bull Run River?

- H_o: There will be no significant change in bed elevation at the locations of a sample of Chinook salmon redds.

<u>Question 2:</u> What is the mean depth of scour and its associated variance at the locations of Chinook salmon redds in the lower Bull Run River?

- H_o: The mean depth of scour will not exceed the assumed upper limit of Chinook egg deposition of 8 inches (Schuett-Hames et al. 1996).

<u>Question 3:</u> What is the percentage of monitored Chinook redds that have significant scour?

- H_o: The percentage of scoured Chinook redds will not be more than 40 percent (Harvey and Lisle 1999).

Forty percent is the level of scour observed by Harvey and Lisle (1999) among Chinook redds in natural gravel patches (compared to 80 percent in fresh dredge tailings).

Research Design

Gravel scour will be measured using sliding-bead type monitors and protocols described in Nawa and Frissell (1993). These devices consist of a thin cable attached at one end to a sediment anchor and equipped with some sort of stop at the other end. Neutrally or positively buoyant beads are strung on the cable between the anchor and the stop. The anchor and cable are inserted vertically into the gravel immediately adjacent to a redd, using a pipe or tube wide enough to accommodate the beads. The insertion pipe or tube is carefully removed so that the beads are buried next to the anchor in the sediment. An excess of cable is left to protrude from the gravel with a marker attached to facilitate its relocation. As gravel is disturbed by high flows, beads are dislodged and slide to the end of the end of the cable at the stop. Periodically, the scour monitoring devices can be relocated and the beads at the end of the cable counted to determine how deep the gravel has been scoured.

Bed elevation at each redd site will be measured using a laser level and a survey rod with a 5-inch base (DeVries and Goold 1999).

Spatial Scale. Chinook redds will be monitored in the lower Bull Run River from river mile (RM) 1.5 –3.7. The City has surveyed this section of the Bull Run River previously for spring and fall Chinook spawning.

Replication Duration. Ten Chinook redds will be selected per year for monitoring. Based on total redd counts from previous surveys, this amount represents between 15 and 100 percent of the estimated population of Chinook redds.

Monitoring will start after HCP Year 5 to allow for 5 years of gravel placements. Monitoring will occur during three years in which high stream flows (>600 cfs) occur. The three years might not be consecutive as some years might pass without high-flow events. Scour monitoring results will be summarized after the three years of data collection are completed.

Parameters. The parameters that will be measured are

- bed elevation (inches below the elevation of a benchmark, which will be established nearby at the time of initial measurement) before and after the incubation season (i.e., as soon as scour monitoring devices are placed and then as soon as possible after the end of March),
- maximum scour depth for the season (inches below the initial bed elevation), and
- maximum flow since the last survey (in cfs, taken from USGS Gauge No. 14140000, 1.8 miles below Reservoir 2).

Sampling Scheme. Chinook redds will be identified during Chinook spawning surveys. The lower Bull Run River, from RM 1.5 to 3.7, will be stratified into reaches based on geomorphic characteristics. These reaches correspond to those used during Chinook spawning surveys. A total of 10 redds will be selected each year for monitoring, with their allocation between reaches corresponding to relative reach length. Within each reach, redds will be chosen as evenly as possible from each of two general categories: redds created in pool tail-outs, riffle crests, and mid-riffle locations; and redds created in gravel associated with obstructions in the channel (e.g., boulders or bedrock outcrops). These two categories of redd locations are expected to differ in the degree of scour they experience, with obstructions contributing to more complex flow patterns.

The re-identification of redds will require a high degree of precision, given the variable nature of streambed topography. Each redd will be re-identified using two pieces of monofilament line of specific length attached at divergent locations on the bank and left in place between surveys. Two scour monitors will be inserted into the sediment adjacent to each active redd, to avoid egg mortality associated with monitor placement. The results of the two monitors will be averaged. Scour monitor placement will occur at least 15 days after redd creation to avoid shock to the embryos during what is an especially sensitive stage.

Bed elevation will be measured when the sliding-bead scour monitors are placed and again as soon as possible after Chinook have completed their gravel-rearing life stages (early to mid-May). Scour monitors will be visited weekly, if possible, during spawning season, to capture the effects of redd superimposition. After spawning season has concluded, scour monitors will be visited as soon as possible after each peak-flow event that exceeds the previous peak-flow event. Peak-flow events will be defined as the highest flow on a given day that exceeds 600 cfs and larger than the highest flow for the previous and following days. Six hundred cfs is the smallest flow calculated to mobilize fine gravel (0.5 inch, intermediate axis). This means that monitors would be visited after flows exceeded 600 cfs, but then would not be revisited until a flow occurred that was higher than the initial flow. At the very least, in the absence of peak flows, scour monitors will be visited twice during the post-spawning period.

Analysis

Data Storage. Data will be stored in a Microsoft® Access database by the City of Portland Water Bureau.

Hypothesis Testing. Bed elevation at the conclusion of the Chinook gravel-rearing season will be compared with the initial bed elevation at each site using a paired t-test ($n=10$, $\alpha=0.05$, $\beta=0.20$). Scour depth for each flow will be compared with the estimated 8-inch upper limit for Chinook egg pockets (Schuett-Hames et al. 1996) using standard t-tests. An estimate for the total impact of scouring on Chinook redds in the lower Bull Run River will be derived for each year that the study occurs by weighting the observed scouring in each of the two categories of redd location according to the relative use of each by Chinook spawners.

Adaptive Management

If spawning gravel placements are not successful, which is defined as the percentage of Chinook redd scour exceeding 40 percent, the City will meet with NMFS to determine options.

Research Protocol for Total Dissolved Gases in the Bull Run River

The level of TDG is the sum of the partial pressures of all gases, including water vapor, dissolved in a volume of water. Elevated levels of TDG in water can have various negative impacts on fish, including the formation of gas bubbles in tissues and the vascular system (gas bubble disease), and over-inflation of the air bladder. Extremely high levels of TDG or long exposure times can lead to immediate or delayed mortality.

Oregon's Water Quality Standards, as enforced by ODEQ, state that the concentration of TDG relative to local barometric pressure should not exceed 110 percent of saturation [OAR 340-041-0031]. An exception will be made when stream flows at a given sampling site exceed the 10-year, 7-day average flood (7Q10), defined as the 7-day rolling average annual high flow that has an average recurrence interval of 10 years.

In 2005, the City initiated a monitoring plan to check TDG levels associated with the water facilities in the Bull Run River. The plan, developed in consultation with ODEQ, identified sites at risk of elevated TDG levels and established a sampling regime specific to each sampling site. The City proposes to monitor TDG levels until enough data are collected to determine whether elevated TDG levels are a concern in the lower Bull Run watershed. This appendix describes sampling sites and protocols for monitoring TDG levels in the lower Bull Run River.

Total Dissolved Gases Research Objective

The TDG research results will be used to determine whether there are locations in the lower Bull Run watershed with elevated concentrations of TDG. The sites will be monitored across a range of flows.

Key Questions/Hypotheses

There are two key questions to be answered by this TDG Monitoring Plan. One of the questions has a hypothesis that will be tested with the monitoring protocol and the other will be addressed by field observation. The questions are:

<u>Question 1:</u> Do any of the monitoring sites exceed the ODEQ standard of 110 percent saturation of TDG?

- H_o: At each monitoring site, the observed TDG concentration will not exceed 110 percent of saturation within any range of flow (as defined in Table F-7) unless flow exceeds the 7Q10 for the lower Bull Run River.

<u>Question 2:</u> How quickly do elevated levels of TDG dissipate downstream when they are observed?

This key question does not have an associated null hypothesis. It involves the collection of information to assist in the adaptive management process.

Monitoring Design

Sites. The City, in conjunction with ODEQ staff, identified all structures within the watershed associated with City operations that could cause elevated levels of TDG. These structures include the spillways, valves, or turbines in which air bubbles could be brought under sufficient pressure to cause their dissolution in water beyond the level of saturation. Monitoring locations were established to monitor the effects of each specific structure on TDG levels, or to provide information on the persistence of TDG downstream. Monitoring sites, the associated structure that increases the risk of elevated TDG concentrations, and the purpose of measuring each site are summarized in Table F-6. The locations of monitoring sites are shown in Figures F-1 and F-2.

Table F-6. TDG Monitoring Sites, Associated Structure, and Purpose of Measuring

Monitoring Site	Associated Structure	Purpose
TDG-1	Dam 2 Spillway	Structure Effects
TDG-1a	Dam 2 Spillway	Downstream Effects
TDG-2	Dam 2 Spillway	Downstream Effects
TDG-3	South Howell-Bunger (HB) Valve	Structure Effects
TDG-4	North HB Valve	Structure Effects
TDG-5	Powerhouse 2	Structure Effects
TDG-6	Diversion Dam	Structure Effects (Upstream Value)
	Powerhouse 2	Downstream Effects
TDG-7	Diversion Dam	Structure Effects (Downstream Value)
TDG-8	Lamprey Weir	Structure Effects (Upstream Value)
	Diversion Dam	Downstream Effects
TDG-9	Lamprey Weir	Structure Effects (Downstream Value)
TDG-10	Dam 1 Spillway	Downstream Effects
	Powerhouse 1	Downstream Effects
TDG-11	Dam 1 Spillway	Structure Effects
TDG-12	Powerhouse 1	Structure Effects

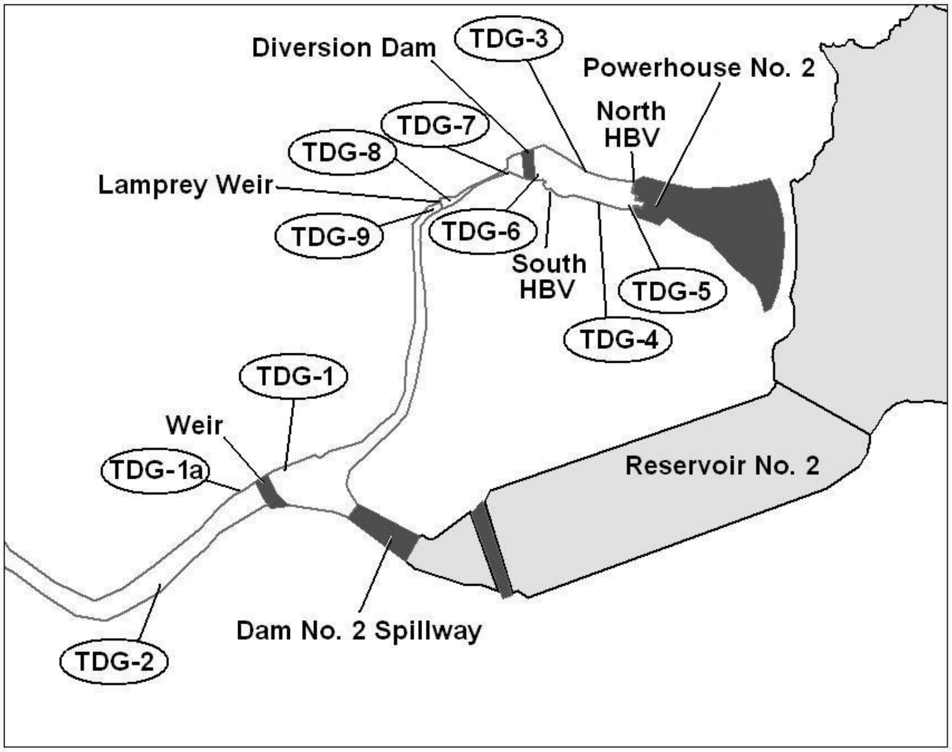

Figure F-1. Locations of TDG Monitoring Sites Associated with Dam 2

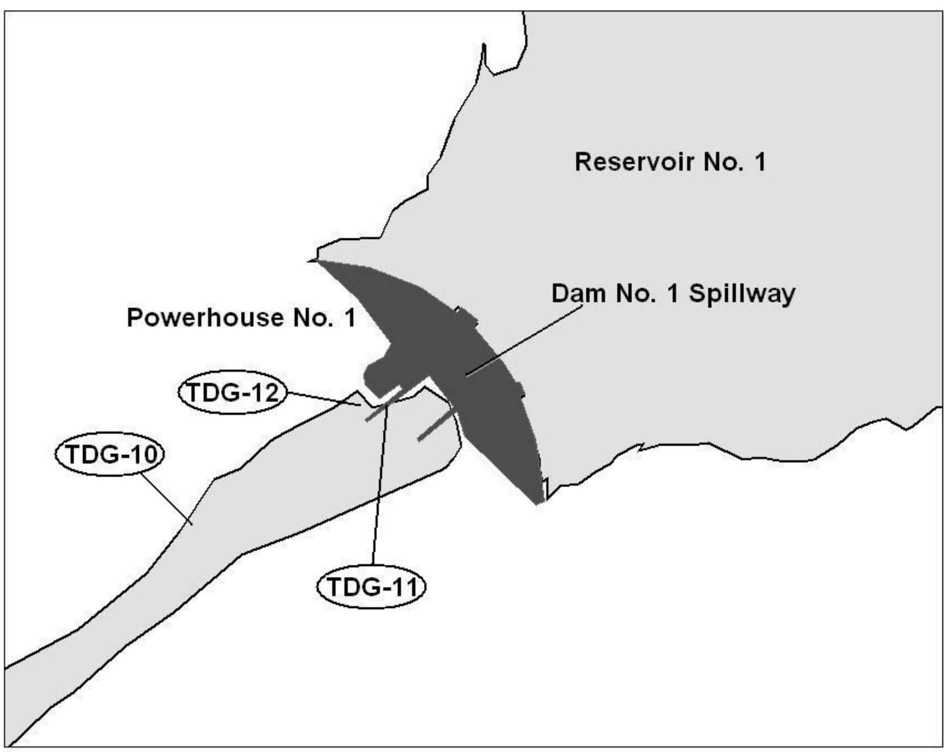

Figure F-2. Locations of TDG Monitoring Sites Associated with Dam 1

Each site has a unique span of possible flows, associated with its longitudinal position along the Bull Run River and its function as a part of the City's water and hydroelectric facilities. Flows passing through each of the two powerhouses are determined by flow sensors in the penstocks and are constrained by the minimum flows required to run the turbines and the maximum flows that the turbines can accommodate. Flows passing over each dam's spillway are estimated by subtracting the powerhouse flows from the instream flows measured at gauging stations upstream of each reservoir. The flows are constrained only by the range of natural variability in the Bull Run River as modified by the water diversions and withdrawals by the City.

For most of the structures, the historical span of flows was divided into three equal parts or flow ranges. Each flow range will be sampled with replication. The ranges of flows for each structure and the number of replicates for sampling are defined in Table F-7. Sites located downstream of structures are for the purpose of monitoring the persistence of TDG concentrations and will be sampled on the same day as the associated upstream sites.

Two Howell-Bunger (HB) valves at Reservoir 2 provide a route for releasing water that bypasses the hydroelectric turbines and the spillway. The HB valves dissipate energy associated with the head pressure behind the dam. Monitoring sites have been located at the outlet of each HB valve. No range of flows has been established for the HB valves. Each site will be sampled several times when the respective valve is in operation.

Table F-7. Flow Ranges and Number of Replicates per Flow Range for Sampling TDG

Structure	Flow Ranges (cfs)	Number of Replicates
Dam 2 Spillway	1,700–6,900	5
	6,900–12,000	5
	12,000–17,200	5
Powerhouse 2	210–700	5
	700–1,200	5
	1,200–1,700	5
South HB Valve	While operating	5
North HB Valve	While operating	5
Diversion Dam	Whenever Powerhouse 2 or HB valve readings are taken	15 to 20
Lamprey Weir	Whenever Powerhouse 2 or HB valve readings are taken	15 to 20
Dam 1 Spillway	2,000–5,500	5
	5,500–8,900	5
	8,900–12,400	5

Table continued on next page

Table F-7. Flow Ranges and Number of Replicates per Flow Range for Sampling TDG, continued

Structure	Flow Ranges (cfs)	Number of Replicates
Powerhouse 1	800–1,200	5
	1,200–1,600	5
	1,600–2,000	5

The 7Q10 for the lower Bull Run was calculated from historical records from October 1, 1959, to September 30, 2003, and is currently estimated to be 5,743 cfs. When flows of this magnitude occur or are exceeded, sampling will continue; however, the ODEQ standard of 110 percent saturation for TDG will not apply. The City will annually update the 7Q10 flow amount for future monitoring purposes.

Scale. All data collected on TDG are site specific. Downstream sites have been included to determine the spatial extent of elevated TDG exposure.

Replication/Duration. Each site will be sampled five times within each flow range; some sampling has already been conducted. The sites associated with the diversion pool dam next to the Water Bureau Headworks facility and the lamprey weir will be sampled whenever the Powerhouse 2 sites are sampled. Downstream sites will be sampled whenever the associated upstream sites are sampled. The HB valve sites will be sampled five times each during valve operation.

Each site will be monitored until the full set of ranges, as defined in Table F-7, has been adequately sampled. Once the relationship of TDG concentrations for each site and set of variables has been established, further monitoring will rely on tracking the environmental variables rather than sampling TDG.

Parameters. On each sampling occasion, the following information will be recorded:

- TDG concentration
- Water temperature
- Date and time of day
- Flow at the respective structure (e.g., spillway or powerhouse)

Sampling. TDG concentrations will be measured using a Common Sensing TBO-DL6 dissolved gas and oxygen meter. Water temperature will be measured with a digital traceable thermometer. Flow at the time of measurement will be obtained from data gathered at the City's water facilities by staff.

Analysis

Linear and non-linear multiple regression will be used to explore the relationship between TDG levels, flow, and temperature at each of the dam spillways and the lamprey weir, and, if possible, to create a model that predicts under what conditions TDG concentrations might exceed 110 percent at each site.

The dissipation of elevated TDG concentrations downstream of their source will be characterized and evaluated across levels of flow using Analysis of Covariance (ANCOVA) of log-transformed data.

If the TDG research hypotheses are rejected, it would indicate there are TDG levels that consistently exceed 110 percent, and/or those levels affect a significant portion of the lower Bull Run River. If that occurs, the City will enter into good-faith discussions with NMFS and ODEQ to review the situation. (See Chapter 9, Monitoring, Research, and Adaptive Management Programs, for details about discussions with NMFS and ODEQ.)

Fish Population Research

Sandy River Basin Juvenile Salmonid Outmigrant Research

This section describes the rationale, objectives, and procedures for conducting research on the emigration of salmonid smolts from portions of the Sandy River Basin. Monitoring salmonid juvenile outmigrants (JOMs) has been recommended by the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) as a key component of assessing an anadromous population's viability. JOM monitoring provides a gauge of freshwater productivity and is particularly important in basins such as in the Sandy River Basin in which freshwater habitat improvements are an important management goal (WLCTRT 2003).

This research approach focuses on determining the number of steelhead and coho salmon smolts from different subwatersheds of the Sandy River Basin. Information will also be collected for spring Chinook smolts (1+ and larger), but the data may not be useful for trend analysis due to the complexities of their life history pattern. The JOMs research is designed to provide biologists with meaningful data to evaluate the long-term trend in smolt abundance for the Sandy River subwatersheds.

JOM Life-Stages to be Studied

The term "salmonid juvenile outmigrant" includes all life stages of salmonids, other than adults, that are leaving a given watershed, at any time of year. The term is not restricted to smolts, but can include emigrating fry and parr. The City, however, will only study the spring emigration of smolts in the Sandy River Basin.

Although the City acknowledges that understanding the magnitude of the emigration of non-smolt juveniles is valuable, especially if significant numbers might be expected to successfully rear in downstream reaches, a thorough study of non-smolt juveniles is beyond the scope of this effort. Quantifying the emigration of non-smolt JOMs is difficult because emigration can occur throughout the year and because monitoring certain life stages, particularly fry, can pose a high risk of mortality to the fish. In order to be meaningful, an estimate of non-smolt JOMs should also be accompanied by an estimate of freshwater survival after emigration from a given subwatershed, further adding to the difficulty and expense. Without an estimate of freshwater survival after emigration, non-smolt JOMs lose effectiveness as a gauge of freshwater productivity. The mortality of smolts after they leave a given subwatershed but before they leave the Sandy River Basin, on the other hand, is considered negligible, based on studies from other basins (e.g., Smith et al. 1999). EDT, for instance, assumes that survival rates through the emigration phase for age 1 Chinook smolts, coho smolts, and steelhead smolts, derived from reviewing the scientific literature, are 98 percent, 98 percent, and 99 percent, respectively.

The City considers the emigration of smolts to be an adequate measure of freshwater productivity in the Sandy River Basin for coho and steelhead. It is unlikely that the mainstem of the Sandy River would provide suitable rearing habitat for non-smolt juveniles that emigrate from clear-water tributaries. The mainstems of the Sandy and the Zigzag rivers are both glacial streams with high levels of suspended solids. Fish productivity has been shown to have an inverse relationship to levels of suspended solids (Bash et al. 2001, Ptolemy 1993). Newcombe and Jensen's (1996) scale of severity index for the effects of suspended solids predicts that the levels of suspended solids observed in the Sandy River during the summer months, from 6 to 40 mg/L, (City of Portland, unpublished data) would lead to sublethal effects on juvenile salmonids ranging from moderate physiological stress to long-term reduction in feeding success. A significant portion of the fall and spring Chinook JOMs in the Sandy River Basin emigrate as fry. The study of outmigrating fry, however, would require different methods.

Smolt emigration is mostly confined to the spring. Data from the North Fork Dam on the Clackamas River suggest that a small portion of the emigration of steelhead, coho, and Chinook smolts in the region can occur during the fall (James Bartlett, pers. comm., 2006). The fall is a difficult time to monitor smolts, however, due to high-flow events and debris in the water. Only salmonid smolts and juveniles that emigrate during the spring will be monitored as a part of this plan.

Geographic Scope of Smolt Studies

Many portions of the Sandy River Basin are neither feasible for nor accessible to smolt monitoring efforts. The mainstem of the Sandy River, for instance, is too large to feasibly monitor and produce meaningful population estimates without risking mass fish mortality. Other smolt-monitoring programs in large river systems have required measures such as checking traps constantly while in operation and subsampling through time (e.g., the Stillaguamish River smolt trap is fished for six hours at a time and checked at least every one to two hours (Griffith et al. 2006). Some streams are inaccessible due to the land ownership patterns or impassable terrain in the surrounding areas.

The City has decided, in consultation with its partners in the Basin and experts in the field, to contribute to a basin-wide, smolt-monitoring effort. This effort proposes to coordinate the limited resources of the various partners in order to collect smolt information for as much of the Sandy River Basin as possible. A portion of those resources will be dedicated to a sampling design that rotates smolt traps between subwatersheds from year to year. The rotation will be designed to provide answers to the key questions identified below.

The City identified a number of streams where monitoring could feasibly take place (Table F-8 on page F-31). The streams make up 50 percent of the available anadromous habitat and represent what is referred to as the "Monitoring Frame." The Monitoring Frame is the area to which monitoring results are directly applicable. The City believes that the Monitoring Frame can also serve as a representative index for the Basin as a whole. The streams listed in Table F-8 span the full range of stream elevations, gradients, temperatures and flow regimes in the Sandy River Basin. The listed streams include reaches with a variety of ownership and management arrangements, and range from relatively pristine streams on federal land near the headwaters of the Sandy River to highly impacted urban streams near the mouth.

Other Smolt Monitoring Designs Considered

Alternative sampling designs that were considered include operating a trap on the mainstem of the Sandy River near the mouth and selecting seven streams to monitor every year for the duration of the HCP.

Trap Operation on the Mainstem Sandy River. Maintaining a trap on the mainstem of the Sandy River near the mouth would have the advantage of potentially providing a Basin-scale estimate of trend. It would require a large amount of effort, however, precluding the monitoring of individual streams. Risk to the trap from vandalism and floating debris and the risk of mass mortality to fish from throughout the Basin would be high. The collected information would also lack the subwatershed-scale resolution that could be used to guide adaptive management.

Trap Operations in Seven Fixed Locations. Operating seven traps in seven fixed locations would have the advantage of providing better estimates of the trend in each trapped stream. It would also have many of the advantages of the rotating design, including greater spatial resolution than trapping near the mouth of the Sandy River. Trapping seven fixed locations, however, would provide information for only 31 percent of the anadromous habitat in the Basin, compared with 50 percent for the rotating design. It is likely that four of the streams selected for fixed-site monitoring would be streams with the largest fish populations, in more pristine condition, and nearer their carrying capacity for juvenile fish. They would not represent the portions of the Basin with the greatest potential for growth in fish populations.

Rotating Trap Operations. The City believes that the rotating design has the greatest potential for providing managers with useful information about the status and trend of JOMs in the Sandy River Basin. The Monitoring Frame overlaps with 72 percent of the habitat for which coho adult spawner numbers are estimated[6]. This compares with an 82 percent overlap if a trap were operated near the mouth of the Sandy River[7]. The Monitoring Frame also overlaps with approximately 52 percent of the habitat for which steelhead adult spawner numbers are estimated and 64 percent of the habitat for which spring Chinook counts are made. The rotating design monitors streams spanning the range of variation in the Sandy River, including streams which are marginal in quality.

If unforeseen difficulties arise, which would prevent the proposed rotating design from answering the key questions identified below, the City and its partners maintain the option of monitoring seven fixed sites, which would be jointly selected from those listed in Table F-8.

Monitoring Objectives

The City is contributing $100,000 per year for the duration of the HCP to the study of JOMs in the Sandy River Basin in order to collect information to aid in the management of anadromous fish populations. The objective of the Sandy River Basin JOM research is to contribute to the viability assessment of salmonid stocks in the Sandy River Basin and support adaptive management by

- collecting information to assess the long-term trend in salmonid smolt populations for as much of the Sandy River Basin as possible.

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[6] A portion (24 percent) of potential coho spawning habitat in the Sandy River Basin is not included in the effort to count adult coho spawners. This is because the stream reaches are turbid with glacial till, preventing reliable visual counts.

[7] All potential smolt trap sites on the Sandy River mainstem are above Beaver Creek. Smolt estimates for the entire Sandy River would also include coho rearing in portions of the river for which there is no estimate of adult coho spawners.

- collecting information to assess the long-term trend in salmonid smolt populations at the subwatershed scale.
- evaluating salmonid smolt production of subwatersheds relative to one another.
- evaluating salmonid smolt physical quality in subwatersheds relative to one another.
- determining the values of various life-history characteristics at a subwatershed scale.

Key Questions

The key questions to be answered by the Sandy River Basin juvenile outmigrant research are the following:

- What is the long-term (20-year) trend in smolt populations for as much of the Sandy River Basin as possible?
    - H_o: The slope of the 20-year trend in the combined population estimate for the Monitoring Frame will be insignificant or significant and positive (α=0.05, β=0.20).
- What is the long-term (20-year) trend in smolt populations at the subwatershed scale for as many Sandy River subwatersheds as possible?
    - H_o: The slope of the 20-year trend in the population estimates for the individual streams within the Monitoring Frame will be insignificant or significant and positive (α=0.05, β=0.20).
- What is the average relative contribution of each subwatershed to the total smolt production for the Monitoring Frame compared with the other subwatersheds?
- When during the year does emigration occur (mean, median, range, variation) for each species in each subwatershed?
- How does smolt quality compare among subwatersheds?
    - Average fork lengths
    - Physical condition
    - Presence or absence of pathogens

Research Design

Number of Traps and Trap Sites. Research on smolt production in the Sandy River Basin will be a joint effort with the Sandy River Basin Partners (Partners). The City and the Partners anticipate operating a total of seven traps each year in the Basin. The City's financial commitment of $100,000 per year, over the term of the HCP, will provide support for maintaining three smolts traps with a City crew. The City also anticipates that three traps will be maintained by the USFS, and one will be maintained by ODFW on Cedar Creek.

Twelve streams have been identified as being feasible and accessible for operating a smolt trap. These sites are summarized in Table F-8.

Table F-8. Streams Accessible for Smolt Trapping and Monitoring

Stream	Miles Used by Anadromous Fish	Land Ownership[a]
Clear Fork Sandy River	4	USFS
Lost Creek	4	USFS
Clear Creek	6	USFS, private
Still Creek	9	USFS
Camp Creek	6	USFS
Zigzag River	7	USFS, private
Salmon River	18	USFS, BLM, private
Cedar Creek	13	Private, state, USFS
Lower Bull Run River (without the Little Sandy River)	8	USFS, City, private
Little Sandy River	6	USFS, BLM, PGE, private
Gordon Creek	7	Metro, BLM, private
Beaver Creek	7	Private
	95 miles total	

[a]Land ownership of the riparian areas is distributed under the U.S. Forest Service (USFS), Bureau of Land Management (BLM), Portland General Electric (PGE), Metro regional government (Metro), the City of Portland (City), the state of Oregon (state), and private owners.

Source: Metro tax lot information 2004

These streams make up 50 percent of the anadromous habitat in the Sandy River Basin. Seven traps will provide monitoring for as little as 26 percent and as much as 37 percent of the anadromous habitat in the Basin in a given year.

Trap Rotation. The allocation of trapping effort in the 12 streams will differ from year to year with the following constraints:

- Seven traps will be operated per year.
- The Bull Run River, Little Sandy River, and Cedar Creek sites will be trapped every year.
- Each rotated site will be trapped four of every nine years.
- As many rotated sites as possible will be sampled once in the first two years, once in the middle two years, and once in the last two years of a 20-year time period. For each of these two-year periods, there will be one site that cannot be trapped. The site that cannot be trapped in Years 1 or 2 will be trapped in both Years 3 and 4. The site that cannot be trapped in Years 10 or 11 will be trapped in both Years 9 and 12. The site that cannot be trapped in Years 19 and 20 will be trapped in both Years 17 and 18.
- Within the above constraints, rotated sites will be trapped according to a schedule that maximizes the number of pair-wise comparisons between them.

These conditions were established to maximize the ability of the City to use the rotation to detect trends and provide pair-wise comparisons between individual subwatersheds.

The City will operate three smolt traps in the Sandy River Basin. Two traps will be in the Bull Run Watershed and an additional site will be trapped as dictated by the rotation design. The Little Sandy River is a special case; the City anticipates operating a trap each year at the Little Sandy Dam site. With the anticipated removal of the Little Sandy Dam in 2008, anadromous fish are expected to recolonize the upper Little Sandy River. Recolonization is expected to result in a positive trend in smolt numbers unrelated to the overall trend of the Monitoring Frame. The Bull Run River trap site, located downstream of the Little Sandy River, will be affected by this recolonization. The Little Sandy estimate will be subtracted from the Bull Run River estimate when calculating trends.

Cedar Creek is another stream in which obstacles to anadromous fish passage will be removed. The recolonization of upper Cedar Creek will be studied in detail by ODFW. In addition to smolt estimates, ODFW plans to collect data on the number of adult and pre-smolt salmon and steelhead in upper Cedar Creek.

The USFS has been running smolt traps for more than 15 years in the upper Sandy River Basin, and the City anticipates that involvement will continue. For this monitoring protocol, the City assumed that the USFS would be able to continue the monitoring of three smolt trap locations.

The trend for the Monitoring Frame will be calculated by using the sum of estimates for all trap sites in a given year and estimating values for sites that were not trapped. Each site will have several years for which an estimate must be calculated. A multiple regression model will be developed for each site to predict the missing years' values. The variables that will be available for the analysis and are likely to have value as predictors of smolt numbers include

- the estimated number of adults in the parental generation in the Sandy River Basin.
- levels of flow at various USGS gauges throughout the Sandy River Basin.
- water temperatures during the summer.

If multiple regression fails to yield a model with predictive value ($R^2 \geq 0.75$), the missing years for each trap will be filled using imputation. Pair-wise comparisons of smolt estimates between any two trap sites will be used to calculate an average ratio between the sites. For every year that a trap site is not monitored, there will be five independent approximations for what its estimate should be, using the site's calculated ratios to the sites that were trapped that year. It is assumed that populations in neighboring streams will have a higher correlation to each other than populations in streams that are widely separated. For this reason, each approximation will be weighted according to the proximity of the contributing trap site to the site for which the imputation is being made. Streams with low smolt estimates, whether because they contain little habitat or because the habitat is marginal, are expected to show high levels of variability, including zero values. For this reason, each approximation will also be weighted according to its average population size or quantity of habitat. The most appropriate method for weighting and dealing with zero values will be determined once the data have been collected.

Duration. The trap rotation is designed to provide useful trend information for both the Monitoring Frame and individual streams within 20 years. Smolt monitoring, however, will continue for the duration of the HCP (50 years).

Fish Capture and Population Estimation. Salmonid smolts will be captured using floating rotary-screw traps. Traps will be fished from mid-March until mid-June each year and will be emptied once per day, while in operation. Species, life stage, fork length, and weight data will be recorded for each fish. Scale samples will also be collected from juvenile and smolt salmonids in order to provide a catalogue for future age analysis. The age of an individual fish can be determined by observing the pattern of widths in the circuli that are created as a scale grows. Knowing the age of individual fish can be useful in determining the average age at smoltification and average fork length-at-age for a given stream.

In addition to fish information, the following environmental data will be collected:

- Daily air temperature
- Continuous water temperature (using temperature dataloggers)
- Relative stage height (from a seasonal gauge)
- Amount of time it takes for five full rotations of the trap screw (measure of current velocity)

Variables. The values of the following variables will be determined for each site each year that the stream is trapped:

- Smolt population (for every species possible)
- Average fork length (by species and life stage)
- Average condition factor $((\text{weight}/(\text{length}^3))\times 100{,}000)$
- Average date of emigration (by species)
- Indications of pathogens

Ancillary environmental information on geomorphic, geographic, land-use, and stream-survey data will be gathered to characterize the watershed above each trap site. These data will be available for future attempts to model the relationship between salmonid smolt population characteristics and environmental variables.

Analysis

Data Storage. Smolt trap data will be maintained by the City using a Microsoft Access® database. Data collected by USFS and ODFW will also be shared with the City, which will be responsible for its analysis and dissemination.

Population Estimates. Population estimates will be calculated using mark-recapture protocols described in Thedinga et al. (1994). Calculations will be made using a modified Lincoln-Peterson estimator that combines smolt data by two-week periods. Variances for the estimates will be calculated using the bootstrap technique suggested in Thedinga et al. (1994). If smolt captures are very small, Darroch Analysis with Rank-Reduction (DARR) will be used to calculate estimates (Bjorkstedt 2000). Procedures for calculating smolt estimates are summarized in the above literature.

The 20-year trend for the Monitoring Frame will be calculated using the four-year running average, as recommended by the WLC-TRT. Individual site 20-year trends will be calculated using the estimates, rather than running averages of the estimates. Emigration timing will be determined using captures corrected by using trap efficiencies. If 10 fish are captured on a given day, for example, and the trap is estimated to have an efficiency of 25 percent (i.e., one in four fish passing the trap site is captured) then the daily number of emigrants is estimated to be 40 (10/0.25). Differences in fork length and average emigration date between sites will be statistically evaluated using Analysis of Variance (ANOVA) coupled with the Tukey multiple-comparisons test.

Adaptive Management

The City will use the data from the JOM research as part of the framework for addressing effectiveness of the HCP as a whole, as described in Chapter 9.

Lower Bull Run River Chinook Population Research

This section describes the sampling methods and protocols for conducting surveys of spawning Chinook adults and redds in the lower Bull Run River. Both spring and fall runs of Chinook salmon may spawn in the lower Bull Run River.

ODFW has conducted surveys of spring Chinook adults and redds in the Sandy River Basin by boat and on foot from 1996 to the present, and surveys on foot of fall Chinook adults and redds in index reaches in the lower Sandy River Basin from 1984 to 2004. These surveys, however, have not included the lower Bull Run River. Weekly surveys of spawning spring and fall Chinook salmon and redds in the lower Bull Run River (RM 0-5.8) were conducted by ODFW in 1997. The City continued weekly surveys from RM 1.5 to RM 5.8 in 1998 and 1999. An index reach of the lower Bull Run River (RM 1.5–RM 3.7) was surveyed by the City in 2005 and 2006.

For HCP Years 1-20, the City will conduct an annual count of spawning Chinook salmon and redds. The lower Bull Run River Chinook population research is designed to provide biologists with meaningful data within a 20-year time frame to evaluate the long-term trend in adult abundance for the Bull Run. The Bull Run data could then be used with information gathered by other agencies to determine the status of listed Sandy River Chinook populations.

Research Objectives

For HCP Years 1-20, the City will conduct annual counts of spawning Chinook salmon and redds in the lower Bull Run River from RM 0—RM 5.8.

The objectives of the lower Bull Run River Chinook population research are to

- document use of the lower Bull Run River by spring and fall Chinook salmon.
- contribute to ODFW's annual assessment of spring Chinook in the Sandy River Basin.

Key Questions/Hypotheses

The key questions to be answered by the research are the following:

- How many Chinook salmon adults enter the Bull Run River to spawn each year? This key question does not have an associated null hypothesis.
- What is the long-term trend (20 years) in spawning Chinook salmon abundance?
  - H_o: The abundance of spawning Chinook salmon will not change significantly over the long term (20 years, α=0.05, β=0.20).
- What is the timing (range of dates and peak date) of adult Chinook presence and redd creation in the lower Bull Run River? This key question does not have an associated null hypothesis.
- What proportion of the spawning Chinook salmon are of hatchery origin?[8] This key question does not have an associated null hypothesis.

The City will also collect otolith[8], tissue, and scale samples from adult carcasses found in the lower Bull Run River. The City will send the samples to ODFW to assist in ODFW's assessment of spring Chinook in the Sandy River Basin. In return, the City will receive information from ODFW about the proportion of unclipped Chinook salmon that are of hatchery origin, the relative number of spring and fall Chinook salmon in the lower Bull Run River, and proportion of Chinook adults showing various life history types (i.e., number of years spent in rivers and number of years spent in the ocean). The compilation of this information, however, depends on analyses conducted by ODFW and is therefore not reflected in the key questions.

Research Design

The study design for the lower Bull Run River Chinook population research will use weekly surveys to count live Chinook adults, Chinook salmon carcasses, and newly created redds. Surveys will be coordinated with the operators at Headworks and the PGE powerhouses to

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[8] The protocols followed by the City will provide the proportion of carcasses found with clipped adipose fins. The proportion of unclipped carcasses that are of hatchery origin will be provided by the analysis of otoliths by ODFW. Otoliths are tiny bones that form a portion of a fish's inner ear. A fish lays down new bone material on the ototlith's edge as it grows, forming bands that record a fish growth rate through time. ODFW thermally "marks" otoliths in hatchery Chinook by exposing juvenile fish to varying water temperatures over time. As fish growth increases in warm water or decreases in cold water, characteristic banding patterns are created, which provide an indication of the fish origin (Schroeder et al. 2005)

maintain flows of 150 cfs or less above the Little Sandy confluence for the duration of each survey. This is the level of flow necessary for safety and for accurate counts.

Scale. The lower Bull Run River will be divided into the following reaches to provide greater spatial resolution and to reflect the reaches used in previous surveys for comparison:

- Reach 1: The confluence of the Bull Run River with the Sandy River to the bottom of the large pool above the Bull Run PGE Powerhouse (RM 0–RM 1.5)
- Reach 2: The bottom of the large pool adjacent to the Bull Run PGE Powerhouse to Bowman's Bridge (RM 1.5–RM 2.3)
- Reach 3: Bowman's Bridge to the confluence of the Little Sandy River (RM 2.3–RM 2.8)
- Reach 4: The Little Sandy River confluence to the top of the pool at Larson's Bridge (RM 2.8–RM 3.7)
- Reach 5: Larson's Bridge to the Road 14 bridge (RM 3.7–RM 4.8)
- Reach 6: The Road 14 bridge to the Reservoir 2 spillway plunge pool (RM 4.8–RM 5.8)

These reaches correspond to those used for the HCP Chinook spawning gravel research. Reaches 2, 3, and 4 are also the reaches used in previous Chinook spawning surveys conducted by ODFW and the City. Reach 4 also corresponds to one of ODFW's probabilistic, randomly selected reaches for the Sandy River Basin steelhead and coho spawning surveys and snorkel surveys. Reaches 5 and 6 are not believed to be used by spawning Chinook salmon. If the results from the first three years indicate that Chinook do not use these reaches, then they will not be surveyed in subsequent years.

Adult and redd abundance and timing information will be summarized at the reach scale. The proportion of hatchery fish will be summarized at the scale of the entire lower Bull Run River.

Replication/Duration. The City is contributing $600,000 over the term of the HCP to the annual survey of spawning Chinook salmon and redds. This amount will fund Chinook population research in the lower Bull Run River for the first 20 years of the HCP. Weekly surveys will be conducted from mid-August through the end of November. There will be no spatial replication, because the entire channel will be surveyed.

Parameters. The following information and samples will be collected during each survey.

- Live Adults
  - Number of adults and number of jacks
  - Species
  - Reach
  - Additional behavioral information (e.g., spawning, defending a redd, etc.)

- Carcasses
  - Species
  - Reach
  - Length (both total length from the snout-tip to the fork of the tail and the middle of the eye to posterior scale—or MEPS —length, in millimeters)
  - Sex
    - If a female, did it die before spawning?
  - Presence of adipose fin
    - If it doesn't have an adipose fin, check for coded-wire tags (CWT). Collect the snout, if it has a CWT.
    - If it has an adipose fin collect
      - An otolith sample (for ODFW determination of hatchery origin)
      - A tissue sample (for NMFS distinction of spring from fall Chinook)
      - A scale sample (for ODFW determination of age and life history)
  - Additional information (e.g., eaten by scavengers, found in the riparian zone)
- Redds
  - Reach
  - Species (assume Chinook unless another species is seen creating or defending it)
  - Size (length x width, ft^2)
  - Substrate size range (visual estimate of the range from approximately the 10^{th} to the 90^{th} percentile of substrate sizes, inches)
  - Channel feature retaining the gravel patch (e.g., behind boulder or bedrock, pool tail, riffle margin, etc.)
  - Evidence of superimposition over a previous redd
- Environmental data
  - Weather (description)
  - Water clarity/visibility
  - Flow (determined from USGS Gauge No. 14140000)

Sampling Scheme. Surveys will be conducted by two observers walking downstream on each side of the channel, when flows can be maintained at or below 150 cfs. All surveys of Reaches 4, 5, and 6 can be conducted by walking. Flows in Reaches 1, 2, and 3 may be too high for walking surveys in October and November due to uncontrolled flow inputs from the Little Sandy River after the Little Sandy Dam has been removed. When flows are in excess of 150 cfs but only up to 500 cfs, in Reaches 1, 2, and 3, these reaches will be surveyed by floating them with kayaks.

Live adults will be counted and their location recorded.

Any carcasses that are found and have a tail will be counted. All carcasses that can be retrieved will be measured and their sex will be recorded. Females will be opened to determine whether they died before spawning. All carcasses will be checked for the presence of an adipose fin. Carcasses with adipose fins will be sampled for otoliths, tissue, and scales. Carcasses without adipose fins will be checked for a CWT using an ODFW detector. The snouts of carcasses with a CWT will be removed and retained. The tail of each carcass will then be removed to prevent it from being recounted during future surveys.

Redds will be counted and their location recorded. The approximate area of each redd and the size of its substrate will be visually estimated. Once these and other data have been collected, each redd will marked with a painted rock comparable in size to those comprising the redd. A flag with the date will also be attached to the bank adjacent to the redd. The painted rock will help distinguish new redds from old ones. Painted rocks from previous surveys that have been dislodged or buried indicate that further spawning activity has occurred at that location. The flag on the bank will aid in confirming the presence of an old redd if the painted rock is missing.

Analysis

Data storage. Monitoring data collected during the HCP will be maintained by the City in a Microsoft® Access database.

Hypothesis Testing. The number and timing of Chinook salmon in the lower Bull Run in a given year will be compared to the number and timing of Chinook salmon in other years. Individual years will not be compared statistically, however, because of the lack of replication.

The long-term (20-year) trend will be calculated using linear regression (α=0.05, β=0.20).

The proportion of hatchery fish in the lower Bull Run in a given year will be compared to the proportion of hatchery fish in other years. Individual years will not be compared statistically, however, because of the lack of replication.

Reporting

All results from the lower Bull Run River Chinook population research will be summarized in the City's HCP compliance reports.

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Appendix G.

Temperature Management Plan for the Lower Bull Run River

Portland Water Bureau
City of Portland, Oregon

Approved by Oregon Department of Environmental Quality
May 2008

Introduction and Background

By authorities delegated from the U.S. Environmental Protection Agency (EPA) under the federal Clean Water Act (CWA), as well as related state statutes, the Oregon Department of Environmental Quality (ODEQ) manages the quality of Oregon's streams, lakes, estuaries, and groundwater.

In 2005, ODEQ completed a Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP) for the Sandy River Basin (ODEQ 2005). This document was required because ODEQ had previously identified that a number of stream segments of the Sandy River did not meet the applicable water quality standards. These stream segments were included on the state's CWA 303(d) list and are referred to as "water quality limited."

One of the identified stream segments was the lower Bull Run River (RM 0–RM 5.8). This section of the lower Bull Run River is located downstream of the Portland Water Bureau's water-supply infrastructure, which includes two dams and related reservoirs as well as the Headworks facility where river flow is diverted into pipes for water supply. Municipal supply operations have an influence on water temperatures in this reach of the lower river due to warming that occurs in the reservoirs and due to reduced river flows below the diversion. The Water Bureau was identified as a designated management agency (DMA) in the TMDL/WQMP and is required to develop an implementation plan, known as a temperature management plan, describing actions that will be taken to comply with the water quality standards.

This temperature management plan (TMP) has been developed in parallel to a Habitat Conservation Plan (HCP) prepared according to Section 10 of the federal Endangered Species Act (ESA). The primary purpose of the HCP is to describe actions the City will take to minimize and mitigate impacts of the Bull Run water supply system on ESA-listed anadromous fish (i.e., salmonids). Salmonid species are native to the Bull Run River. Salmonid spawning and rearing were first blocked in 1921 by the Headworks diversion dam at RM 6.0, and are now limited to the lower Bull Run River because of the rock weir at the base of the Dam 2 stilling pool at RM 5.8.

A key element of the HCP involves improving water temperature conditions for spawning and rearing salmonids. Because this ESA objective substantially overlaps with the objectives of the applicable CWA water temperature standard and because action is specifically required by the load allocation for temperature in the Lower Bull Run River established in the Sandy River Basin TMDL, a single integrated strategy has been developed to address both federal requirements. The HCP describes the integrated strategy in detail. This temperature management plan provides a summary (and cross references to the HCP) to describe the actions to be taken to comply with the CWA requirements.

Water Quality Criteria and Beneficial Uses of the Bull Run

In 2004, EPA approved Oregon's revised water quality standards for temperature and cold water fish. According to the new water quality standards, the designated beneficial use for the lower Bull Run River is "core cold-water habitat." Core cold-water habitat is defined as "waters that are expected to maintain temperatures within the range generally considered optimal for salmon and steelhead rearing…during the summer" [OAR 340-041-0002(13)].

The water quality standard includes three applicable components [OAR 340-041-0028]:

- Numeric temperature criteria
- Natural condition temperature criteria
- Air temperature exclusion

Numeric Temperature Criteria

The numeric criteria are described in Table 1.

Table 1. Numeric Water Quality Criteria for Lower Bull Run River

River Reach	Time Period	Habitat Use	Numeric Criterion (7-Day Average Maximum)
River Mile 0 to 5.3	June 16 to August 14	Salmonid rearing	16°C
	August 15 to June 15	Salmonid spawning	13°C
River Mile 5.3 to 5.8	June 16 to October 14	Salmonid rearing	16°C
	October 15 to June 15	Salmonid spawning	13°C

Source: ODEQ 2005

Natural Condition Temperature Criteria

If the natural conditions in a stream exceed the numeric criteria, ODEQ's temperature standard states that the natural condition temperatures become the applicable temperature criteria for the water body [OAR 340-041-0028].

Temperature data for the Bull Run River were not recorded prior to the construction of the Bull Run water supply system. ODEQ and the Water Bureau used two methods to estimate the natural condition temperatures for the lower Bull Run River: modeling and a surrogate stream.

- **Models.** ODEQ and the Water Bureau used models to estimate the natural condition temperatures that likely occurred in the lower Bull Run River prior to construction and operation of the City's water supply system which began in the 1890s (City of Portland 2004). The models used physical characteristics from field studies and meteorological data to provide estimated daily average temperatures for the Bull Run River.

- **Surrogate Stream.** Modeling results were verified through comparisons with temperatures in the Little Sandy River. The Little Sandy River is a tributary of the Bull Run River and is geomorphically similar enough to create similar water temperature conditions during most seasons (ODEQ 2005). ODEQ identified the Little Sandy River as an appropriate surrogate stream for estimating natural condition temperatures in the lower Bull Run River on a daily, or real-time, basis.

In the Sandy River Basin TMDL (ODEQ 2005), ODEQ defined the natural condition temperature criteria for the Bull Run River as follows:

> Meet the measured 7-day moving average of the daily maximum temperature for the Little Sandy River with the following specific exceptions:
>
> - Between August 16 and October 15, the lower Bull Run River temperature may be up to 1 °C higher than the Little Sandy River temperatures measured at RM 3.8.
> - If the 7-day moving average of the daily maximum ambient air temperature (as measured at U.S. Geological (USGS) Gauge No. 1414000 in the lower Bull Run) is above 27 °C, then the lower Bull Run River temperature may be up to 1.0 °C higher than the Little Sandy River temperatures measured at RM 3.8.
> - If the 7-day moving average of the daily maximum ambient air temperature (as measured at U.S. Geological (USGS) Gauge No. 1414000 in the lower Bull Run) is above 28 °C, then the lower Bull Run River temperature may be up to 1.5 °C higher than the Little Sandy River temperatures measured at RM 3.8.

The Little Sandy River has a smaller drainage area, shorter water transit times, and lower natural flows than the Bull Run River. Analysis of these differences resulted in ODEQ's definition of these exceptions.

Air Temperature Exclusion

The ODEQ temperature standard also includes the following exception:

> Air temperature exceeds the 90th percentile of the 7-day average of the daily maximum air temperature calculated in a yearly series over the historical record [OAR 340-041-0028(12)(D)(c)]

If this situation occurs in the lower Bull Run River, neither the numeric or natural condition criteria would apply.

Summary of ODEQ Requirements for the Lower Bull Run River

ODEQ's requirements for the lower Bull Run River apply both the numeric criteria and the natural condition temperature components of the standard, as follows:

- **Numeric criteria.** When the estimated natural condition temperatures of the Bull Run River (determined using measured temperatures in the Little Sandy River) are at or below the numeric criteria in Table 1, the numeric criteria apply.
- **Natural condition temperatures.** When the estimated natural conditions of the Bull Run River (determined using measured temperatures in the Little Sandy River) are above the

numeric criteria in Table 1, the natural condition temperature criteria (with exceptions) and 90th percentile air temperature exclusion apply.

Figure G- 1 shows modeled natural temperatures for the lower Bull Run River compared with measured Little Sandy River temperatures (2000–2001) and with ODEQ's numeric criteria.

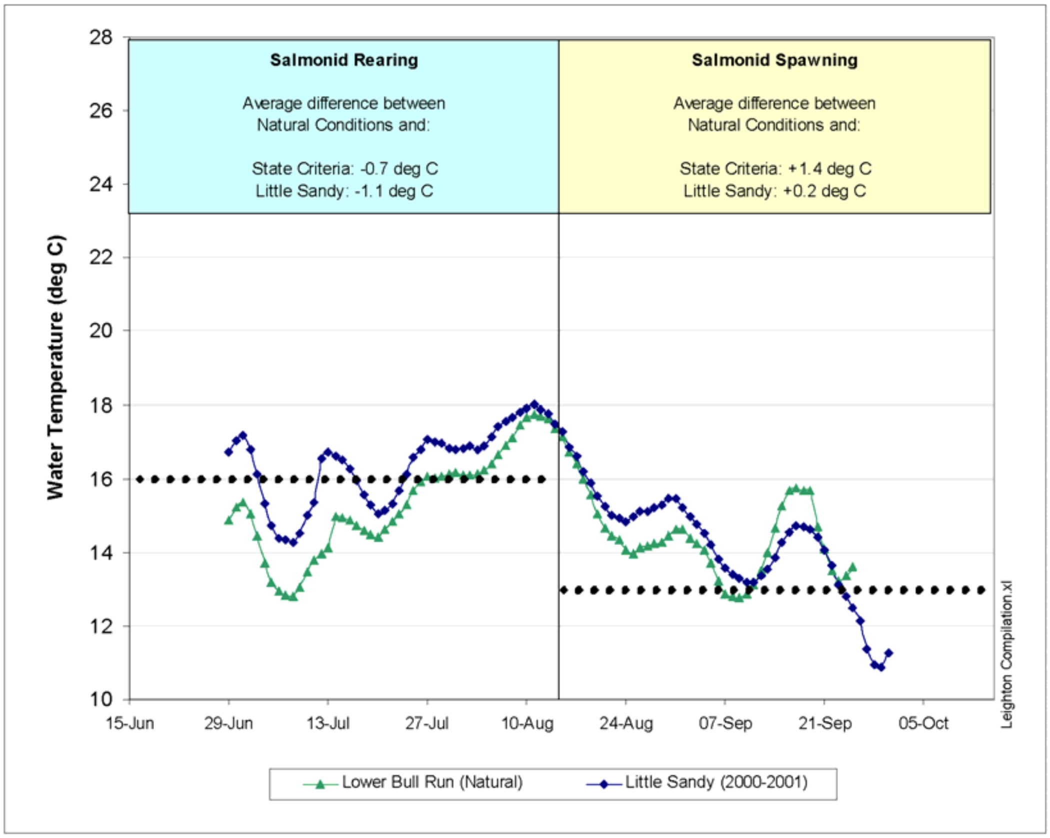

Figure 1. Comparison of Bull Run River Natural Temperatures, Measured Sandy River Temperatures, and ODEQ Numeric Criteria

Source: Leighton 2001

Management Strategies

To comply with ODEQ's water temperature requirements for the Bull Run River, the Water Bureau has defined three management strategies. The strategies include riparian forest protection, reservoir flow releases, and modification of intake tower structures. These strategies are part of the overall strategy to protect listed salmonids as described in the HCP.

Strategy #1 — Riparian Forest Protection

The Water Bureau owns land along 5.3 miles of the lower Bull Run River (1,650 acres) in a patchwork pattern from RM 0—RM 6.0. The Water Bureau-owned lands have been subjected to minimal human or natural disturbance during the past 90 years. Shade conditions on Water Bureau land were evaluated as part of the analyses leading to this TMP, including solar pathfinder estimates of incident radiation and gray card estimates of shading. Vegetation conditions were also assessed (Beak 1998, Leighton 2001, 2002). Canopy coverage is generally good and provides riparian habitat comparable to unmanaged late-seral forest. The east-west orientation of the river does, however, limit the effective shading of the channel.

Action: The Water Bureau will continue managing these lands to protect riparian shade conditions so that their value to protecting instream water temperatures will be maintained. The Water Bureau will not cut trees within 200 feet of the river's average high water level on Water Bureau-owned lands for the 50-year term of the HCP. Exceptions will include selective tree cutting to construct, maintain, and operate water supply and treatment facilities, water monitoring facilities, power lines, roads, and bridges, or to protect infrastructure or human safety from hazards. If trees are removed, the Water Bureau will plant replacement trees. (See full description in **Measure H-2** [Riparian Land Protection] in Chapter 7 of the HCP and the Appendix of this document.)

Monitoring: The Water Bureau will survey and measure shading along the lower Bull Run River with a solar pathfinder once every five years. Results will be reported in an annual report. (See Monitoring and Evaluation section below, as well as description of compliance monitoring for Measure H-2 in Chapter 9 of the HCP.)

Strategy #2 — Reservoir Flow Releases

The Water Bureau will release water into the lower Bull Run River to manage water temperature.

Action: Flow releases will be managed to meet temperature management objectives (see Temperature Management Objectives section below). The amount of water released will vary within a range (20–40 cfs) as needed to meet the target temperatures, depending on the weather. Amounts at the higher end of the range will be released in warmer weather. In cooler weather, amounts at the lower end of the range will be released so that cool water in the reservoir can be conserved for later in the season.

Existing multiple-level intakes at Reservoir 1 will also be used to selectively withdraw water at different depths during the summer season to conserve and strategically use cooler water. Early releases will come from upper strata of the reservoir while the temperatures are still cool. As the reservoir warms, releases will be taken from deeper, colder strata.

(See full descriptions in **Measures F-1** [Minimum Instream Flows, Normal Water Years], **F-2** [Minimum Instream Flows, Water Years with Critical Seasons], and **T-1** [Pre-infrastructure Temperature Management] in Chapter 7 of the HCP and the Appendix of this document.)

Monitoring: The Water Bureau will check hourly USGS flow and water temperature records for the lower Bull Run River. (See Monitoring and Evaluation section below, as well as compliance monitoring measures for Measures F-1, F-2 and T-1 in Chapter 9 of the HCP.)

Strategy #3 — Multiple Intakes at Dam 2 and Stilling Pool Bypass Pipe

To improve the Water Bureau's ability to manage water temperature, the Water Bureau will modify the intake structures at Dam 2 and modify the stilling pool basin below Dam 2. The planned multiple-level intake towers will create two important capabilities:

- selective withdrawal of water from Reservoir 2 at depths with desired temperatures
- separation of flow going to the water system from flow going to the lower river

Unlike the towers at Dam 1, the Dam 2 towers do not currently have multiple-level intakes. The existing Dam 2 intakes draw from the deeper strata in the reservoir which makes it difficult, if not impossible, to conserve cooler water for later in the season. Planned modification of the stilling pool will allow cool water to flow quickly through the stilling pool to the lower river, preventing unnecessary warming. These infrastructure modifications will enable the Water Bureau to meet ODEQ's temperature requirements.

Action: The Water Bureau will design, construct, and operate modified intake structures at Dam 2 to enable selective withdrawal of cool water at different depths and to conserve cool water for late in the season. The Water Bureau will also modify the stilling pool basin to route cool water more quickly to the lower river. (See the full description in **Measure T-2** [Post-infrastructure Temperature Management] in Chapter 7 of the HCP and the Appendix of this document.)

Monitoring: The Water Bureau will document progress toward completion of Dam 2 tower and spillway rock weir improvements in annual reports. When the modified intakes are operational, the Water Bureau will check and record hourly temperature records for the Little Sandy River, as well as for the lower Bull Run River. (See Monitoring and Evaluation section below, as well as compliance monitoring for Measure T-2 in Chapter 9 of the HCP.)

Temperature Management Objectives and Predicted Results

The Water Bureau acknowledges that successful temperature management is constrained by the current infrastructure. The Water Bureau is unlikely to consistently meet the ODEQ water temperature standard in very warm and very dry weather conditions without new infrastructure.

Until the new infrastructure can be designed and constructed (see Strategy #3), the Water Bureau will manage the reservoir releases to achieve temperatures at Larson's Bridge (RM 3.8) that do not exceed 21 °C. This 21 °C maximum will allow continued growth for the cold water fish. The Water Bureau has analyzed the expected results of implementing this strategy using the model described above and data for 2005 summer season weather conditions (June through October). The results are shown in Figure 8-3 in Chapter 8 of the HCP. The results indicate that the lower Bull Run River is likely to exceed both Little Sandy

River temperatures and the ODEQ numeric criteria, but will be less than 21 °C. Temperatures during the summer and early fall will usually be substantially less than 21 °C, particularly during the majority of the spawning season for spring and fall Chinook. During the remainder of the year (not shown in Figure 8-3 of the HCP), temperatures in the river will also be substantially below 21°C (City of Portland 2004).

When the new infrastructure is in place, the Water Bureau will manage the reservoir releases to achieve temperatures at Larson's Bridge that meet the criteria described above in the Water Quality Criteria section. Temperature results expected with the new infrastructure have been analyzed and are shown in Figure 8-4 in Chapter 8 of the HCP. The analysis, based on 2005 weather data, indicates that lower Bull Run River temperatures will be near to or less than Little Sandy temperatures for much of the summer season. At times, lower Bull Run River temperatures will exceed Little Sandy temperatures in September and October, but will be less than ODEQ's 13 °C criterion for spawning.

In addition to the exception criteria evaluated by ODEQ in the TMDL, the Water Bureau developed an additional exception for the HCP to account for situations when the Water Bureau has limited or no ability to manage water temperature. These situations can include unexpected power grid interruptions, downed power lines, equipment failures, loss of computer contact with the Dam 2 intake towers, emergency responses at Headworks as required to assure compliance with federal Safe Drinking Water Act standards, mandatory annual testing of the protection devices at the powerhouse, and other circumstances that preclude the use of the intake towers or diversion pool at the Water Bureau's water supply Headworks. This exception will also apply for the Water Bureau's compliance with ODEQ temperature requirements. Since disruptions of the kinds mentioned above have the potential to also affect our ability to meet water supply objectives, the Water Bureau will have incentives to make rapid assessments and repairs. The Water Bureau also maintains an active asset management program emphasizing proactive maintenance and risk analysis based repair and replacement, which will help avoid failures of water system equipment and infrastructure. If this exception is triggered and results in disruptions in our ability to meet temperature requirements in the lower Bull Run River, the Water Bureau will take action to limit the duration to as short a time as possible and will be in communication with ODEQ as needed during the episode.

Time Frame

Implementation of the Bull Run temperature management strategies will occur as part of implementing the HCP. The Water Bureau is already implementing HCP Measures F-1, F-2, and T-1. Performance data are available from the Water Bureau. Annual reporting will begin after Year 1 of the HCP (first report expected in 2009).

The Water Bureau has completed conceptual design for Measure T-2. The preliminary and final design process began in late 2007. Construction of the intake tower and spillway improvements will be complete in 2012.

Costs and Funding

Implementing the Bull Run temperature management strategies will involve both capital and operating costs. The costs are shown in Table 2, and additional detail is provided in Chapter 11 and Appendix I of the HCP.

The Water Bureau will pay these costs with revenues from the sale of water to customers. Capital costs will be paid from bonds sold to fund the Capital Improvement Program. Operating funds will be paid from annual operating budgets.

Table 2. Costs to Implement the Three Management Strategies

	Operating Costs	Capital Costs
Strategy #1 Riparian Forest Protection	N/A [a]	N/A [a]
Strategy #2 Reservoir Flow Releases	$14,992,955 [b]	$10,279,944 [b]
Strategy #3 Multiple Intakes at Dam 2 and Stilling Pool Bypass Pipe	N/A [a]	$7,203,000

[a] Costs are limited to staff time and have not been calculated separately.

[b] Only a portion of the reservoir release costs are attributable to temperature management. The releases are also to achieve river flow objectives. The dollar portion for temperature has not, however, been calculated separately. Total costs are shown. Reservoir releases will also be monitored. The total estimated cost for flow and temperature monitoring is $18,200 per year, or $910,000 (in 2006 dollars) over the 50-year term of the HCP.

Monitoring and Evaluation

Oregon law requires that DMAs monitor and evaluate progress toward achieving TMDL allocations and water quality standards [OAR 340-042-0080(3)(a)(C) and OAR 340-042-0040(4)(1)(M)].

Methodology for Collecting and Analyzing the Data

The Water Bureau will check hourly and daily maximum Bull Run River water temperatures and hourly flow records collected by the USGS. The Water Bureau will use established USGS sites on the lower Bull Run and Little Sandy rivers as flow and water temperature compliance locations. The Water Bureau has already installed real-time temperature monitoring equipment at Larson's Bridge and at the USGS gauge on the Little Sandy River.

Daily water temperatures will be recorded at the Larson's Bridge site on the lower Bull Run (USGS Gauge No. 14140020, Bull Run River at Larson's Bridge, RM 3.8), and also from USGS Gauge No. 14141500 (Little Sandy River at RM 1.95). Daily flows will be recorded at USGS

Gauge No. 14140000 (Bull Run River at RM 4.7 near Bull Run, Oregon). Monitoring locations are shown in Figure 2.

Daily maximum air temperatures will be recorded at the Water Bureau's Headworks facility below Dam 2 (approx. RM 6).

The Water Bureau will also monitor riparian conditions in the lower Bull Run River. Shade conditions along the lower Bull Run River will be recorded once every five years. Any tree cutting and/or replanting will be recorded annually and included in the annual report.

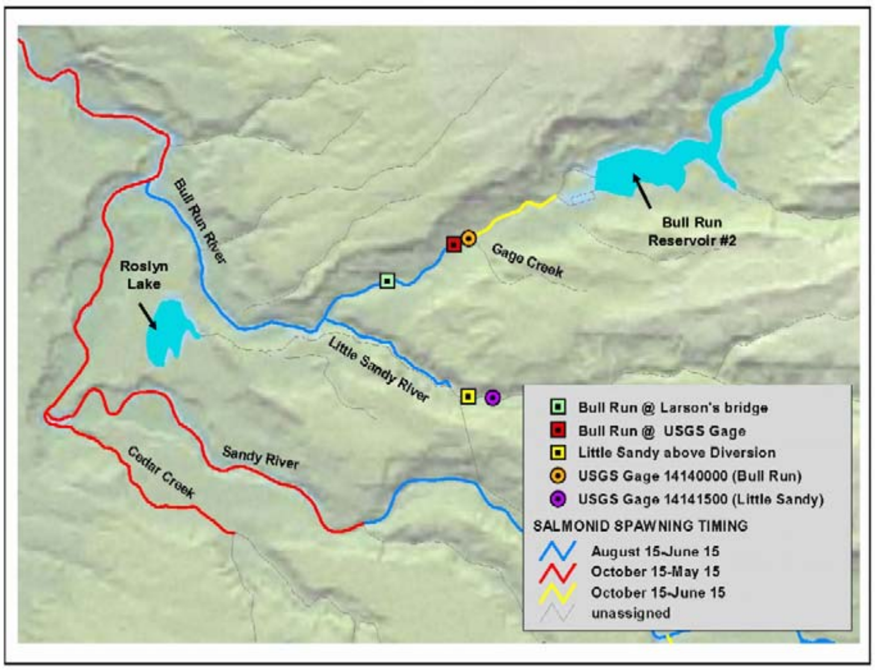

Figure 2. Monitoring Locations in the Bull Run and Little Sandy Rivers

Party Responsible for Collecting, Analyzing, and Reporting Information

The Water Bureau will collect, analyze, and report water temperature information to ODEQ on an annual basis. The annual report for the TMP is anticipated to be prepared on the same schedule as the longer annual report for the HCP because the temperature data reported will be the same. Timing for the first annual report will be determined in consultation with ODEQ and is expected to occur in 2009.

The Water Bureau's Resource Protection and Planning Group Director or designee will be responsible for ensuring that annual reports are produced and delivered to ODEQ. The Resource Protection and Planning Group Director is on the Water Bureau's management team and reports directly to the Water Bureau Administrator.

Staff involved in collecting, analyzing, and reporting data will include personnel responsible for operating the reservoirs to meet flow and temperature criteria, as well as scientists and engineers with monitoring and regulatory compliance duties. The Water Bureau will continue to contract with the USGS to monitor and maintain the flow gauges, as well as to analyze and conduct quality control of the flow data.

Adaptive Management

The Water Bureau has incorporated adaptive management approaches into both the HCP and this TMP. Acknowledgement of the infrastructure limitations on water temperature management resulted in a two-phased approach to comply with ODEQ's water temperature standard. If the infrastructure changes are effective and the Water Bureau is able to meet ODEQ's temperature requirements, the Water Bureau will then be in compliance and additional incremental improvements in strategy will not be necessary. The HCP will be in place as an enforceable contract for a period of 50 years.

Ongoing adjustments will be made in reservoir operations (e.g., to vary flow releases according to the weather during the summer season); the resulting water temperatures will be reported in an annual report. ODEQ's comments on the annual reports, especially about any compliance problems, will be used by the Water Bureau to plan improvements for subsequent operating seasons.

The Water Bureau has also acknowledged the potential effects of climate change on Bull Run watershed hydrology and has developed a statistical approach to identify changes that might affect the feasibility of continuing to release flows into the lower Bull Run River, as described in the HCP (see Chapter 10 of the HCP). These analyses will be provided to ODEQ if the results indicate a need to change temperature management strategies during the term of the HCP.

Chapter 9 in the HCP describes an adaptive management framework that will be used if the actions described above do not result in compliance with ODEQ's temperature requirements. Specifically, the Water Bureau and ODEQ will meet to discuss monitoring results that indicate the Water Bureau is not implementing the strategies as planned, or the three strategies are not successful in meeting the requirements. The TMP and HCP will be amended if necessary to incorporate new approaches. The HCP anticipates formal progress meetings approximately every five years and major decision milestones at Years 20, 30, and 35.

Evidence of Compliance with Land Use Requirements

The Water Bureau owns 4,782.8 acres of land in the Bull Run watershed, most of which is located around Reservoir 2 and downstream along the Bull Run River. This Water Bureau-owned land is located in Clackamas County. Approximately 95 percent of the physical drainage is federally owned land administered by the Mt. Hood National Forest. The Water Bureau holds multiple special use permits and easements to allow operation of water-system-related facilities on federal land.

Clackamas County established a River and Stream Conservation Area in 1997. Section 704 of the Clackamas County zoning and development ordinance (Title 12) defines requirements for all streams, which vary by stream size and designation. Fish-bearing streams are addressed and policies are defined for the Sandy, Salmon, and Zigzag rivers. Provisions include setbacks and native vegetation protection requirements. Section 1002 also includes provisions dealing with erosion control and habitat protection.

All three of the strategies outlined in this temperature management plan are consistent with current county land use regulations and policies. Land use, zoning, and building permits will be obtained for any new or modified structures that may require them. No changes in zoning are anticipated.

References

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Appendix

Note: The Temperature Management Plan approved by DEQ included an appendix excerpting text from the draft HCP for measures H-2, F-1 and F-2, and T-1 and T-2. See chapter 7 of the final HCP for the text of these measures.

Appendix H. Methodology to Assess Impact of the Long-term Climate Changes on Bull Run River Streamflow

The City of Portland (City) will track and analyze the impact of long-term climate changes on Bull Run River reservoir inflows as part of the Habitat Conservation Plan (HCP) (see Chapter 10, Changed Circumstances). Three statistical approaches will be applied to the Bull Run reservoir inflow data to determine whether there has been a significant decline in flow: linear regression, comparison of means/medians, and the number of critical flow years.

Two of the three tests, the comparison of means/medians and the number of critical flow years, require a sample size with enough power to enable comparisons. For this reason, the City will use a 20-year data set (from 2005–2025) to calculate the mean/median and the proportion of critical flow years. The tests will be implemented in 2025 and once every five years thereafter with cumulative year totals.

Specific statistical software packages are identified in this appendix. If better statistical software options are available in the future, those options will be discussed with NMFS and selected if appropriate.

Data Set

Streamflow for the Bull Run River and some of its tributaries has been measured by the U.S. Geologic Survey (USGS) since 1907. Historical streamflow measures for Little Sandy River extend as far back as 1911. However, the most reliable data without interruption starts in 1920.

The City evaluated the available data to select a data set that would be stationary and would include enough years to be able to detect a statistically significant trend. A data set of Bull Run reservoir inflows from 1946 to 2004 (59 years) was selected. The 1946–2004 data are stationary. Between 23 and 37 years of data are needed in order to detect a trend of magnitude 0.5 – 0.1 percent per year when the data are stationary (Weatherhead 1998). The 1946-2004 data set is also expected to be large enough to detect a decline in average flow as a possible impact of long-term climate change on Bull Run streamflow.

Test Procedures

The following statistical tests will be implemented in 2025 and every five years after that through 2050 to detect changes in Bull Run reservoir inflow due to long-term climate changes: linear regression, comparison of means or medians, and number of critical flow years. Future analyses will contrast the 1946-2004 data set first with the data for 2005–2025 and then with additional data gathered during the five-year increments (i.e., 2005–2030, 2005–2035, etc.). If two out of three tests indicate a decline in flow, the conclusion will be in favor of the two tests.

Linear Regression

The City will detect and measure the trend in the flow using a linear regression model. The slope of the fitted trend line to the natural log of the data shows the average percentage growth (positive or negative), for the time period over the entire range of data. The semi-log regression model is of the form:

$$\ln(Flow) = \alpha + \beta t + u$$

in which t is time (in this case, 1946–2004), α and β are the intercept and the slope of the trend line, and u is the error term of the regression.

The trend detection test procedure is as follows.

- Compute the natural log of the flow data for the entire 1946–2025 period.
- Fit a regression trend line to the data in which the independent variable t takes the value 1946–2025.
- Check the level of significance of the coefficients.
- If the coefficient of t is equal to or less than -0.007, then that indicates a downward trend in flow.

When detecting a change in the rate of decline, the investigator should perform a test procedure for point of inflection or deflection. A Chow test can determine whether there is a statistically significant change in the coefficient of the trend at any specified point in time. Most regression software packages are capable of performing the Chow test. The test is usually found under the Coefficient Stability Test category. The Chow test can determine whether there is a change in magnitude or direction of the trend during the 2005–2025 period.

Comparison of the Means and/or Medians

For this test, the means or medians of flow data can be compared and statistically tested to see whether they are significantly different. Unlike the median, the sample mean is affected by outliers that are unusually large or small compared with the rest of the data. Moreover, the mean is a computed number that might not actually occur. Therefore, in cases where outliers exist, comparison of medians is a more reliable test. Tests of both the mean and the median are suggested here.

Test of Means

In order to detect a downward trend in streamflow, the mean of historical flow data, 1945–2004, will be statistically tested against the mean of flow during the 2005–2025 period.

Let μ_0 and μ_1 be the 1946–2004 and 2005–2025 mean flows respectively. The null hypothesis is

$$H_n: \mu_0 = \mu_1.$$

This is tested against the alternative hypothesis,

$$H_a: \mu_0 > \mu_1.$$

A t-test with 0.05 level of significance can determine whether there is a statistically significant decline in the mean flow. The test procedure is as follows.

- Determine the critical value $t_{0.05}$ with $(n+m-2)$ degrees of freedom, where n and m are number of flow observation in 1946–2004 and 2005–2025 periods respectively.
- Compute means $\overline{x}_0$ and $\overline{x}_1$, and standard deviations, s_0 and s_1, of the 1945–2004 and 2005–2025 flows respectively.
- Compute the test statistic,

$$t = \frac{\overline{x}_0 - \overline{x}_1}{\sqrt{\frac{(n-1)s_0^2 + (m-1)s_1^2}{n+m-2}} \sqrt{\frac{1}{n} + \frac{1}{m}}}.$$

- If $t > t_{0.05}$, then reject the null hypothesis and conclude that there is a decline of statistical significance in mean flow. If $t < t_{0.05}$, then do not reject the null hypothesis.

Microsoft® Excel or other statistical software can be used to implement the above test statistics.

Test of Medians

A similar test of hypotheses can be done using medians instead. The null and alternative hypotheses are:

$$H_{n:}\ M_0 = M_1$$
$$H_a\text{: } M_0 > M_1$$

The Mann-Whitney-Wilcoxon (MWW) test procedure with 0.05 level of significance is as follows:

- Determine the critical value, $z_{0.05}$.
- Combine $N = n + m$ observations from 1946–2004 and 2005–2025 flows, but keep track of which sample the observation was drawn from.
- Order and rank the N observations from smallest, rank 1, to the largest, rank N. For observations of equal magnitude, assign each the average of their ranks.
- Compute the sum of ranks, T_0, for the observations in the 1946–2004 sample.
- Compute the test statistics,

$$z = \frac{T_0 - \frac{m(N+1)}{2}}{\sqrt{\frac{mn(N+1)}{12}}}$$

- If $|z| > z_{0.05}$, then reject the null hypothesis and conclude there is a decline of statistical significance in the median flow. If $|z| < z_{0.05}$, then do not reject the null hypothesis.

There are no specific modules that perform the MWW test in Microsoft® Excel. However, the test can be set up manually according to the explained procedure and performed in Excel. Also, most statistical software packages perform MWW or other versions of test of equality of medians.

Number of Critical Flow Years

The third approach to detecting the long-term climate impact is to observe the increase in the frequency of occurrence of critical flow years. The 1946–2004 Bull Run inflow data were used to determine the cutoff for the critical flow. The proprietary statistical software Crystal Ball was used to fit an empirical distribution to the flow data. The best-fitted distribution was a gamma distribution with scale 41 and shape 8 parameters. The goodness-of-fit tests show a Kolmogrov value of 0.05 with a p-value 0.99 and an Anderson-Darling value of 0.14 with a p-value of 0.99.

Crystal Ball was used to simulate ten thousand flow numbers according to the fitted gamma distribution. Figure H- 1 shows the empirical simulated gamma distribution and the 10th percentile cutoff flow.

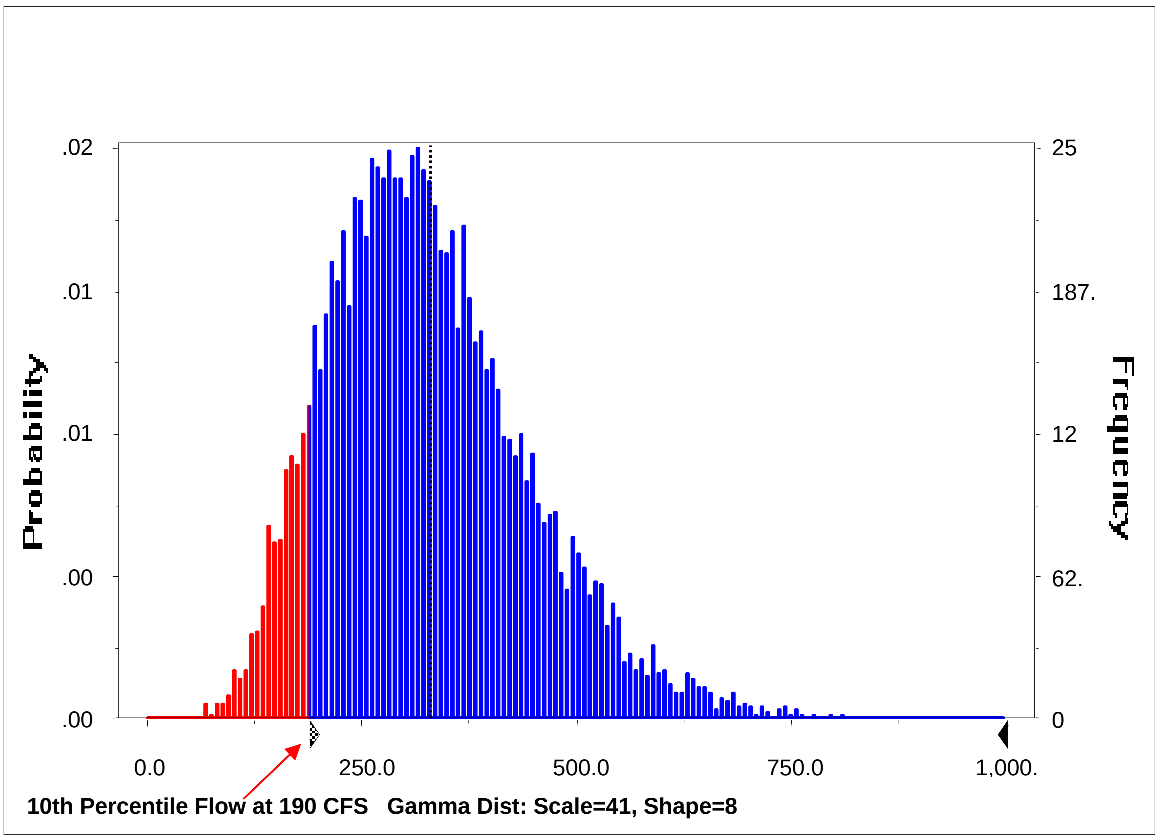

Figure H-1. Bull Run Flow Empirical Frequency Distribution, 1946–2004

The lowest 10th percentile flow cutoff, 190 cubic feet per second (cfs), was determined from the simulated flow numbers. Critical flow years are defined as years in which the June–October average flow is equal to or less than 190 cfs. According to this criterion, the five years between 1946 and 2004 are considered critical flow years (see Table H-1). The proportion of critical flow years during the 1946–2004 period is 5 out of 59 or 0.085.

Table H-1. Critical Flow Years for 1946–2004

Years	Flow (cfs)
1965	130
1987	133
1991	188
1992	162
2003	158

Sources: USGS Gauges No. 14138850, Bull Run River at RM 14.8; No. 14138870, Fir Creek at RM 0.6; No. 14138900, North Fork Bull Run River at approximately RM 0.2; and No. 14139800, South Fork Bull Run River at RM 0.6.

Given the determined cutoff flow and the proportion of critical flow years, let p_0 and p_1 be the 1946–2004 and 2005–2025 proportion of critical flow years respectively. The null and alternative hypotheses are:

$$\mathrm{H_n}\text{:}\ p_0 = p_1$$
$$\mathrm{H_a}\text{:}\ p_0 < p_1$$

A z test with 0.05 level of significance can determine whether there has been a statistically significant increase in the proportion of the critical flow years. The test procedure is as follows:

- Use the critical flow year cutoff flow of 190 cfs to determine the number of critical flow years for 2005–2025 and compute the proportion $\hat{p}_1$. The proportion $\hat{p}_0$ is already computed as 0.085.
- Compute the test statistic

$$z = \frac{\hat{p}_1 - \hat{p}_0}{\sqrt{\dfrac{\hat{p}_1(1-\hat{p}_1)}{m} + \dfrac{\hat{p}_0(1-\hat{p}_0)}{n}}}$$

- If $z > z_{0.05}$, then reject the null hypothesis and conclude that there is an increase of statistical significance in the frequency of the critical flow years. If $z < z_{0.05}$, then do not reject the null hypothesis.

This test can be set up manually and performed in Microsoft® Excel.

The City will use simulation software in the future to determine the shift in the frequency of occurrence of critical flow years.

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Appendix I. Timeline of Bull Run Water Supply Habitat Conservation Plan Projected Costs in 2008 Dollars[a]

			HCP Year										
			2006-2008	2008-2013	2013-2018	2018-2023	2023-2028	2028-2033	2033-2038	2038-2043	2043-2048	2048-2053	2053-2058
	Type of cost	50-year total		(1-5)	(6-10)	(11-15)	(16-20)	(21-25)	(26-30)	(31-35)	(36-40)	(41-45)	(46-50)
Habitat Conservation		**$70,666,277**											
Bull Run Measures	**TOTAL**	**$39,007,387**	**$905,000**	**$11,160,496**	**$1,926,726**	**$1,465,924**	**$5,856,275**	**$2,742,199**	**$2,337,390**	**$3,123,121**	**$3,376,338**	**$2,900,594**	**$3,213,323**
Flow Measures													
Measures F-1 and F-2 (Minimum Instream Flows)	O&M	$16,082,750	$0	$393,803	$660,255	$926,709	$1,193,161	$1,460,840	$1,736,275	$2,012,936	$2,289,596	$2,566,257	$2,842,918
Measures F-1 and F-2 (Capital Maintenance of Well Field)	Capital	$10,905,993	$0	$607,859	$1,160,381	$433,125	$4,557,024	$1,175,269	$495,025	$1,004,095	$980,652	$228,247	$264,315
Measure F-3 (Flow Downramping)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure F-4 (Little Sandy Flow Agreement)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Temperature Measures													
Measure T-1 (Pre-infrastructure Temperature Management)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure T-2 (Post-infrastructure Temperature Management)	Capital	$9,613,132	$642,000	$8,971,132	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure T-2 (Modification of Spillway Rock Weir)	Capital	$208,000	$94,000	$114,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Lower Bull Run Measures													
Measure H-1 (Spawning Gravel Placement)	O&M	$928,288	$0	$212,180	$79,568	$79,568	$79,568	$79,568	$79,568	$79,568	$79,568	$79,568	$79,568
Measure P-1 (Walker Creek Fish Passage)	Capital	$989,000	$169,000	$820,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-2 (Riparian Land Protection)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Bull Run Reservoir Measures													
Measure R-1 (Reservoir Operations)		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure R-2 (Cutthroat Trout Rescue Equipment Purchase)	Capital	$15,000	$0	$15,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure R-2 (Cutthroat Trout Rescue Staff Time)	O&M	$265,225	$0	$26,523	$26,523	$26,523	$26,523	$26,523	$26,523	$26,523	$26,523	$26,523	$26,523
Measure R-3 (Reed Canarygrass Removal)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure O&M-1 (Bull Run Infrastructure Operation and Maintenance)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure O&M-2 (Bull Run Spill Prevention)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Offsite Measures	**TOTAL**	**$16,598,090**	**$0**	**$7,056,599**	**$5,235,648**	**$2,064,162**	**$433,908**	**$301,296**	**$301,296**	**$301,296**	**$301,296**	**$301,296**	**$301,296**
HCP Years 1-5	***$6,522,691***												
Measure H-5 (Gordon 1A & 1B LW Placement)	O&M	$214,531	$0	$214,531	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-6 (Trout 1A LW Placement)	O&M	$53,633	$0	$53,633	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-7 (Trout 2A LW Placement)	O&M	$15,017	$0	$15,017	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-11 (Sandy 1 Riparian Easement and Improvement)	Capital	$103,243	$0	$103,243	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-12 (Sandy 2 Riparian Easement and Improvement)	Capital	$633,537	$0	$633,537	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-13 (Gordon 1A & 1B Riparian Easement and Improvement)	Capital	$732,087	$0	$732,087	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-16 (Alder 1A & 2 Riparian Easement and Improvement)	O&M	$403,587	$0	$403,587	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-22 (Boulder 1 Riparian Easement and Improvement)	Capital	$136,093	$0	$136,093	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-26 (Boulder 0 & 1 LW Placement)	O&M	$48,270	$0	$48,270	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure P-2 (Alder 1 Fish Passage)	O&M	$402,246	$0	$402,246	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure P-3 (Alder 1A Fish Passage)	O&M	$80,449	$0	$80,449	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure P-4 (Cedar 1 Fish Passage)	Capital	$3,700,000	$0	$3,700,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
HCP Years 6-10	***$4,801,739***												
Measure H-3 (Little Sandy 1 & 2 LW Placement)	O&M	$96,539	$0	$0	$96,539	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-4 (Sandy 1 & 2 Log Jams)	O&M	$670,409	$0	$0	$670,409	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-8 (Sandy 1 Reestablishment of River Mouth)	O&M	$1,186,624	$0	$0	$1,186,624	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-9 (Sandy 1 Channel Reconstruction)	O&M	$402,246	$0	$0	$402,246	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-10 (Turtle Survey and Relocation)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-15 (Cedar 2 & 3 Riparian Easement and Improvement)	Capital	$460,705	$0	$0	$460,705	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-17 (Cedar 2 & 3 LW Placement)	O&M	$429,062	$0	$0	$429,062	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-19 (Salmon 1 Riparian Easement and Improvement)	Capital	$211,179	$0	$0	$211,179	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-23 (Salmon 2 Miller Quarry Acquisition)	Capital	$335,205	$0	$0	$335,205	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-25 (Salmon 2 Carcass Placement)	O&M	$4,157	$0	$0	$4,157	$0	$0	$0	$0	$0	$0	$0	$0
Measure F-5 (Cedar Creek Purchase Water Rights)	Capital	$1,005,614	$0	$0	$1,005,614	$0	$0	$0	$0	$0	$0	$0	$0
HCP Years 11-15	***$1,630,254***												
Measure H-14 (Sandy 3 Riparian Easement and Improvement)	Capital	$61,007	$0	$0	$0	$61,007	$0	$0	$0	$0	$0	$0	$0
Measure H-18 (Sandy 8 Riparian Easement and Improvement)	Capital	$234,643	$0	$0	$0	$234,643	$0	$0	$0	$0	$0	$0	$0
Measure H-20 (Salmon 2 Riparian Easement and Improvement)	Capital	$337,886	$0	$0	$0	$337,886	$0	$0	$0	$0	$0	$0	$0
Measure H-21 (Salmon 3 Riparian Easement and Improvement)	Capital	$112,628	$0	$0	$0	$112,628	$0	$0	$0	$0	$0	$0	$0
Measure H-24 (Salmon 2 Miller Quarry Restoration)	Capital	$475,991	$0	$0	$0	$475,991	$0	$0	$0	$0	$0	$0	$0
Measure H-27 (Zigzag 1A Channel Design)	O&M	$268,164	$0	$0	$0	$268,164	$0	$0	$0	$0	$0	$0	$0
Measure H-28 (Zigzag 1A & 1B Riparian Easement and Improvement)	Capital	$113,118	$0	$0	$0	$113,118	$0	$0	$0	$0	$0	$0	$0
Measure H-29 (Zigzag 1A, 1B, & 1C Carcass Placement)	O&M	$26,816	$0	$0	$0	$26,816	$0	$0	$0	$0	$0	$0	$0
Purchase LW	O&M	$530,450	$0	$132,613	$132,613	$132,613	$132,613	$0	$0	$0	$0	$0	$0
Land Maintenance	O&M	$3,012,956	$0	$301,296	$301,296	$301,296	$301,296	$301,296	$301,296	$301,296	$301,296	$301,296	$301,296
Design and Permitting	Capital	$100,000	$0	$100,000	$0	$0	$0	$0	$0	$0	$0	$0	$0

			HCP Year										
			2006-2008	2008-2013	2013-2018	2018-2023	2023-2028	2028-2033	2033-2038	2038-2043	2043-2048	2048-2053	2053-2058
	Type of cost	50-year total		(1-5)	(6-10)	(11-15)	(16-20)	(21-25)	(26-30)	(31-35)	(36-40)	(41-45)	(46-50)
Habitat Fund	**TOTAL**	**$5,000,000**	**$0**	**$1,000,000**	**$1,750,000**	**$1,000,000**	**$1,250,000**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Measure H-30	O&M	$2,500,000	$0	$500,000	$875,000	$500,000	$625,000	$0	$0	$0	$0	$0	$0
Measure H-30	Capital	$2,500,000	$0	$500,000	$875,000	$500,000	$625,000	$0	$0	$0	$0	$0	$0
Staff Time	**TOTAL**	**$10,060,800**	**$0**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**
60% of Total	O&M	$10,060,800	$0	$1,006,080	$1,006,080	$1,006,080	$1,006,080	$1,006,080	$1,006,080	$1,006,080	$1,006,080	$1,006,080	$1,006,080
Monitoring		**$5,175,200**											
Compliance	**TOTAL**	**$910,000**	**$0**	**$91,000**	**$91,000**	**$91,000**	**$91,000**	**$91,000**	**$91,000**	**$91,000**	**$91,000**	**$91,000**	**$91,000**
Flow and Water Temperature Monitoring (USGS)	O&M	$910,000	$0	$91,000	$91,000	$91,000	$91,000	$91,000	$91,000	$91,000	$91,000	$91,000	$91,000
Effectiveness	**TOTAL**	**$1,750,000**	**$0**	**$175,000**	**$175,000**	**$175,000**	**$175,000**	**$175,000**	**$175,000**	**$175,000**	**$175,000**	**$175,000**	**$175,000**
Effectiveness Monitoring for Instream Projects	O&M	$1,750,000	$0	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000
Staff Time	**TOTAL**	**$2,515,200**	**$0**	**$251,520**	**$251,520**	**$251,520**	**$251,520**	**$251,520**	**$251,520**	**$251,520**	**$251,520**	**$251,520**	**$251,520**
15% of Total	O&M	$2,515,200	$0	$251,520	$251,520	$251,520	$251,520	$251,520	$251,520	$251,520	$251,520	$251,520	$251,520
Research		**$7,013,400**											
Habitat Research	**TOTAL**	**$575,000**	**$0**	**$50,000**	**$125,000**	**$50,000**	**$50,000**	**$50,000**	**$50,000**	**$50,000**	**$50,000**	**$50,000**	**$50,000**
Gravel Monitoring	O&M	$500,000	$0	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Scour Monitoring	O&M	$75,000	$0	$0	$75,000	$0	$0	$0	$0	$0	$0	$0	$0
Population Research	**TOTAL**	**$5,600,000**	**$0**	**$650,000**	**$650,000**	**$650,000**	**$650,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**
Adult Chinook Population Data	O&M	$600,000	$0	$150,000	$150,000	$150,000	$150,000	$0	$0	$0	$0	$0	$0
Juvenile Outmigrant Data (Smolt Trapping)	O&M	$5,000,000	$0	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
Staff Time	**TOTAL**	**$838,400**	**$0**	**$83,840**	**$83,840**	**$83,840**	**$83,840**	**$83,840**	**$83,840**	**$83,840**	**$83,840**	**$83,840**	**$83,840**
5% of Total	O&M	$838,400	$0	$83,840	$83,840	$83,840	$83,840	$83,840	$83,840	$83,840	$83,840	$83,840	$83,840
Adaptive Management		**$10,353,600**											
Habitat Fund	**TOTAL**	**$4,000,000**	**$0**	**$388,889**	**$388,889**	**$444,444**	**$1,000,000**	**$666,667**	**$666,667**	**$222,222**	**$222,222**	**$0**	**$0**
Measure H-30	O&M	$2,000,000	$0	$194,444	$194,444	$222,222	$500,000	$333,333	$333,333	$111,111	$111,111	$0	$0
Measure H-30	Capital	$2,000,000	$0	$194,444	$194,444	$222,222	$500,000	$333,333	$333,333	$111,111	$111,111	$0	$0
Insurance Fund	**TOTAL**	**$3,000,000**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$1,250,000**	**$1,250,000**	**$250,000**	**$250,000**
Insurance Fund Requirements at Years 31, 36, and 41	O&M	$3,000,000	$0	$0	$0	$0	$0	$0	$0	$1,250,000	$1,250,000	$250,000	$250,000
Staff Time	**TOTAL**	**$3,353,600**	**$0**	**$335,360**	**$335,360**	**$335,360**	**$335,360**	**$335,360**	**$335,360**	**$335,360**	**$335,360**	**$335,360**	**$335,360**
20% of Total	O&M	$3,353,600	$0	$335,360	$335,360	$335,360	$335,360	$335,360	$335,360	$335,360	$335,360	$335,360	$335,360
Terrestrial Wildlife Conservation													
Wildlife Measures													
Measure W-1 (Minimize Impacts to Spotted Owls)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure W-2 (Minimize Impacts to Bald Eagles)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure W-3 (Minimize Impacts to Fishers)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Capital Requirements		**$34,984,061**	$905,000	$16,627,394	$4,242,528	$2,490,621	$5,682,024	$1,508,603	$828,359	$1,115,206	$1,091,764	$228,247	$264,315
Total O&M Requirements		**$58,224,416**	$0	$5,621,390	$7,776,534	$5,126,709	$5,500,959	$4,694,359	$4,969,794	$6,274,233	$6,550,893	$5,716,443	$5,993,104
CAPITAL AND O&M GRAND TOTAL		**$93,208,477**	$905,000	$22,248,784	$12,019,062	$7,617,331	$11,182,983	$6,202,962	$5,798,153	$7,389,439	$7,642,656	$5,944,690	$6,257,418

[a]This cost estimate is the City's best estimate for the timing of measure funding but implementation of measures may vary from this timeline.
[b]No estimated costs are included in the relevant staff time line item for this measure.

Appendix J. The Life Cycle of Salmonids

The material in this appendix has been adapted from Section 3.2.3 of Seattle Public Utility's Cedar River Habitat Conservation Plan*.*

Introduction

Salmon and steelhead trout are members of several species in the biological family Salmonidae (also referred to as "salmonids"). This appendix provides background on the basic life cycle of salmonids with some information on the variations that occur among species.

The Redd

Most members of the family Salmonidae begin life in streams, or sometimes lakes, when eggs and sperm are released into clean gravel (Wydoski and Whitney 1979). Female salmon or trout typically dig several egg pockets in the gravel in a stream bed. Shortly after digging each egg pocket, the female will release a portion of her eggs as the male releases sperm. The eggs settle onto the gravel and, after a short interval, the female will move upstream to repeat the process. As she digs the next egg pocket, the excavated gravel from the new pocket covers the previously deposited eggs. The spawning fish will create several egg pockets over the course of several days. The combined group of egg pockets is called a redd.

Eggs, Alevins, and Fry

The eggs develop for variable lengths of time, depending on species, subspecies, individual variability, water temperature, and general incubation conditions. After 1-3 months, the eggs hatch into larval fish called alevins. Newly hatched alevins burrow downward into the gravel to avoid light within 48 hours of hatching (Fast 1987). The alevins remain in the gravel and gradually continue to develop, using the energy stored in their attached yolk sacs. Figure J-1 shows an alevin with an attached yolk sac. After 1-3 months—depending primarily on the species and water temperature—absorption of the the yolk sacs is almost complete. At this point, the alevins move up through the gravel, swimming towards the light and the current. The alevins emerge from the gravel as free-swimming fry. Most salmonids fry have several dark oval or circular markings on their sides called parr marks (see Figure J-1).

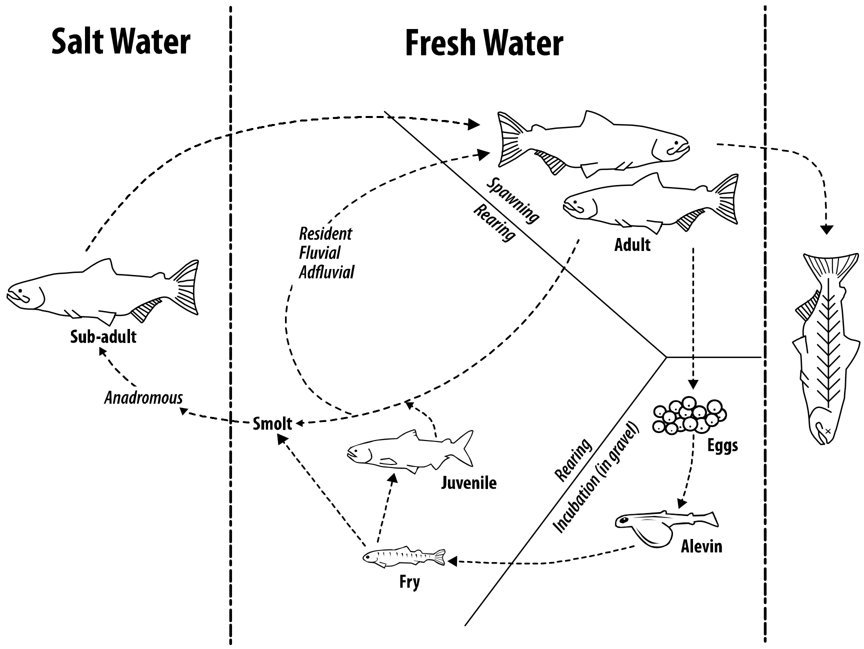

Figure J-1. Salmonid Life Cycle

Juvenile Salmonids

There is considerable variation in life history strategies among species and populations of salmonids during the juvenile stage (Groot and Margolis 1991). Species vary with respect to the amount of time spent in fresh water and where the young fish grow, or rear, to maturity. Juvenile Chinook, winter steelhead, and coho typically remain in their natal streams for extended periods and produce relatively smaller runs of adults, compared with other salmon species.

Spawning

As salmon and trout approach sexual maturity, they begin a spawning migration, returning to their natal stream, although a small percentage strays to other streams (Hasler 1966; Groot and Margolis 1991). The maturing adults exhibit changes in body form and color; individuals of some species return to their natal streams with highly developed coloring on their sides, dark spots, and/or a hooked snout for which the genus is named (*Oncorhynchus* is derived from the Greek for “hooked nose”).

Females choose the site of the redd and defend it from other females. Males fight over the females, aggressively chasing off other males after acceptance by a female. In some species, a few males (and occasionally females) in a population will return to spawn a full year earlier than the majority of the population. These precocious males (called jacks) can successfully fertilize some of the eggs during the act of spawning by a full-size, adult pair.

Chinook, coho, and chum salmon are semelparous, meaning that individuals breed only once and die after spawning. Winter steelhead are iteroparous, which means that individuals breed more than once and may live to spawn in several years (Groot and Margolis 1991). One important consequence of the return of anadromous fish is that nutrients from the ocean are carried into the fish's natal stream once the individual dies and its body decomposes. This source of nutrients has been shown to contribute to aquatic and riparian productivity (Bilby et al. 1996).

Life Histories

Salmonids that spend their entire lives within a fairly limited stream range are said to exhibit a *resident* life history. Fish with *fluvial* life histories spawn and perhaps rear for a period in a small tributary but move into larger streams and rivers later in life. Fish with *adfluvial* life histories spawn and sometimes rear in streams, then move into lakes after maturity.

Fish that leave fresh water to grow and mature in the ocean before returning to spawn are *anadromous*. Juvenile anadromous fish with parr marks lose the marks as their physiologies change in preparation for leaving fresh water and entering salt water. At this stage, the fish are called smolts.

Salmon and winter steelhead spend from one to several years in the ocean, depending on species, sub-species, and individual variability.

Literature Cited

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Hasler, A.D. 1966. Underwater guidepost: homing ofs salmon. University of Wisconsin Press. Madison, Wisconson. 155 p.

Wydoski, R.S., and R.R. Whitney. 1979. Inland fishes of Washington. The University of Washington Press, Seattle, WA.

Appendix K. Data Source Information for Maps

Table K-1. Data Source Information for Maps

Theme	Source(s)	Date	Scale
Figure 2-1. Location of the Bull Run Watershed in the Sandy River Basin			
1:100k Sandy Basin streams with EDT reach delineation[a]	Portland Water Bureau & Ecotrust modification of OGDC file[b]	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Oregon dams	Oregon Department of Fish and Wildlife	2004	—
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Bull Run watershed hydrologic unit boundary	Ecotrust	2003	—
Columbia River	U. S. Geological Survey	1996	1:100K
Major and principal highways	City of Portland GIS data	2003	—
Hillshade from 30m DEMs[c]	Ecotrust	1999	n/a
30m DEMs	Ecotrust	1999	n/a
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k
Urban growth boundary	Metro Regional Government	2002	—
Mt. Hood National Forest boundary	U.S. Forest Service	1997	—
Figure 2-2. City of Portland Water System and Service Area			
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Bull Run watershed hydrologic unit boundary	Ecotrust	2003	—
Major rivers	U. S. Geological Survey	1996	1:100K
Lakes	Mount Hood National Forest		1:24K
Portland Water Bureau retail and wholesale service area boundaries	Metro Regional Government Data Resource Center	1999	—
Columbia South Shore Well Field and Former Powell Valley Road Water District Drinking Water Protection Zone boundaries	Portland Water Bureau GIS data	2004	1:1200
Figure 4-1. Watersheds of the Sandy River Basin			
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Oregon dams	Oregon Department of Fish and Wildlife	2004	—
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Watershed hydrologic unit boundaries	Ecotrust	2003	—
Columbia River	U. S. Geological Survey	1996	1:100K
Major and principal highways	City of Portland GIS data	2003	—
Hillshade from 30m DEMs	Ecotrust	1999	n/a

Table K-1. Data Source Information for Maps, continued

Theme	Source(s)	Date	Scale
Figure 4-1. Watersheds of the Sandy River Basin, continued			
30m DEMs	Ecotrust	1999	n/a
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k
Urban growth boundary	Metro Regional Government	2002	—
Mt. Hood National Forest boundary	U.S. Forest Service	1997	—
Figure 4-4. Relative Water Temperatures in Sandy River Basin Streams and Tributaries			
Forward Looking Infrared Radar (FLIR) thermography monitoring data	Oregon Department of Environmental Quality	2001	—
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Oregon dams	Oregon Department of Fish & Wildlife	2004	—
Columbia River	U. S. Geological Survey	1996	1:100K
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Watershed hydrologic unit boundaries	Ecotrust	2003	—
Urban growth boundary	Metro Regional Government	2002	—
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k
Major and principal highways	Metro Regional Government	2003	—
Hillshade from 30m DEMs	Ecotrust	1999	n/a
Figure 4-6. Sandy River Basin Vegetation Cover Types			
1998 GAP vegetation[d]	Natural Heritage	1998	n/a
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Watershed hydrologic unit boundaries	Ecotrust	2003	
Columbia River	U. S. Geological Survey	1996	1:100K
Major and principal highways	Metro Regional Government	2003	—
Hillshade from 30m DEMs	Ecotrust	1999	n/a
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k
Urban growth boundary	Metro Regional Government	2002	—
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Oregon dams	Oregon Department of Fish & Wildlife	2004	—
Figure 4-7. Land Cover and Existing Uses in the Sandy River Basin			
Landsat satellite imagery	U. S. Geological Survey	2000	—
Major and principal highways	Metro Regional Government	2003	—
Columbia River	U. S. Geological Survey	1996	1:100K
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k

Table K-1. Data Source Information for Maps, continued

Theme	Source(s)	Date	Scale
Figure 4-7. Land Cover and Existing Uses in the Sandy River Basin, continued			
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Oregon dams	Oregon Department of Fish & Wildlife	2004	—
Lakes	Mount Hood National Forest	—	1:24K
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Watershed hydrologic unit boundaries	Ecotrust	2003	—
Urban growth boundary	Metro Regional Government	2002	—
Hillshade from 30m DEMs	Ecotrust	1999	n/a
Mt. Hood National Forest boundary	U.S. Forest Service	1997	—
Figures 4-8 through 4-13. Watersheds in the Sandy River Basin (Lower, Middle, Upper Sandy River; the Salmon River; the Zigzag River; and the Bull Run River)			
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Oregon dams	Oregon Department of Fish and Wildlife	2004	—
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Watershed hydrologic unit boundaries	Ecotrust	2003	—
Columbia River	U. S. Geological Survey	1996	1:100K
Highways and freeways	City of Portland GIS data	2003	—
Hillshade from 30m DEMs	Ecotrust	1999	n/a
30m DEMs	Ecotrust	1999	n/a
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k
Urban growth boundary	Metro Regional Government	2002	—
Mt. Hood National Forest boundary	U.S. Forest Service	1997	—
Figures 5-5, 5-6, 5-14, 5-15, 5-23, 5-24, 5-32, and 5-33. Current and Historical Distribution (Fall Chinook, Spring Chinook, Winter Steelhead, Coho)			
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Oregon dams	Oregon Department of Fish & Wildlife	2004	—
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Watershed hydrologic unit boundaries	Ecotrust	2003	—
Major streets and highways	Metro Regional Government	2003	—
Hillshade from 30m DEMs	Ecotrust	1999	n/a
Urban growth boundary	Metro Regional Government	2002	—
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k
Columbia River	U. S. Geological Survey	1996	1:100K

Table K-1. Data Source Information for Maps, continued

Theme	Source(s)	Date	Scale
Figures 7-2 through 7-7. Offsite Habitat Conservation Measure Locations (Little Sandy River; Lower, Middle, and Upper Sandy River; Salmon River, Zigzag River)			
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Sandy Basin hydrologic unit	Ecotrust	Varies	Varies
Sandy sub-basin hydrologic unit	Ecotrust	2003	—
Columbia River	U. S. Geological Survey	1996	1:100K
Hillshade from 30m DEMs	Ecotrust	1999	n/a

— indicates metadata that are unavailable or unknown
[a]EDT–Ecosystem Diagnosis and Treatment; see Appendix D for more information
[b]OGDC–Oregon Geospatial Data Clearinghouse, available at http://www.gis.state.or.us/data/alphalist.html
[c]DEM–digital elevation map
[d]GAP–GAP Analysis Program, a project conducted by the U.S. Geological Survey, available at http://gapanalysis.nbii.gov/portal/server.pt

Appendix L. References

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Appendix M. Changes or Additions to HCP After Fall 2007 Public Review Draft

Chapter or Appendix	Document		Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
	Page	Section			
Ch 2	2-7	2.2.1	Clarification that none of the covered species is found in Bull Run Lake	No	No
	2-13	2.4	Clarification that City funding of ODFW hatchery operations is not covered	No	No
Ch 3	3-1	3.1	Addition of eulachon (*Thaleichthys pacificus*) as a covered species because of the National Marine Fisheries Services decision in March 2008 to initiate a status review of the species (a decision on the listing determination is expected by November 8, 2008)	No	No
	3-3	3.3	Clarification that federal ESA coverage can be provided for Bull Run Lake and federal roads under Section 7	No	No
Ch 4	4-14	4.1.5	Addition of a brief overview of the conclusions from the University of Washington study on climate change in the Bull Run watershed	No	No
	4-32 and 4-33	4.3	Explanation of the data source for the watershed stream miles in Table 4.8 and correction of watershed mileages to conform to mileages in the Sandy River Basin Characterization Report	No	No
Ch 5	5-2	5.1	Explanation that eulachon sometimes spawn in the lower Sandy River in the vicinity of the area that will be affected by some of the City's HCP measures.	No	No

Chapter or Appendix	Document		Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
	Page	Section			
Ch 5			Correction of GIS-generated historical stream mileages for fish distribution to mileages based on stream surveys:	No	Yes
	5-56 and	Table 5-3	Winter steelhead		
	5-73	Table 5-6	Coho		
	5-78	5.4.2	Addition of information on eulachon including species status, life history and diversity, distribution, abundance and productivity, harvest in the Sandy River Basin, reasons for decline, and threats to survival.	No	No
Ch 7	7-17	Measure T-2	Inclusion of Table 7-6. Appropriate Numeric Temperature Criteria Clarification of conditions under which Bull Run water temperature target will be adjusted or an exception to the temperature targets would occur per the ODEQ Total Maximum Daily Load (TMDL) document.	No	No

Chapter or Appendix	Document		Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
	Page	Section			
Ch 7			For offsite riparian easement and improvement measures: • Clarification that the City will consider obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide • Clarification that easement management will include control of invasive plant species	No	No
	7-39	Measure H-11	Reach Sandy 1		
	7-40	Measure H-12	Reach Sandy 2		
	7-40	Measure H-13	Reaches Gordon 1A and 1B		
	7-45	Measure H-14	Reach Sandy 3		
	7-45	Measure H-15	Reaches Cedar 2 and 3		
	7-45	Measure H-16	Reach Alder 1A and 2		
	7-51	Measure H-18	Reach Sandy 8		
	7-54	Measure H-19	Reach Salmon 1		
	7-55	Measure H-20	Reach Salmon 2		
	7-55	Measure H-21	Reach Salmon 3		
	7-55	Measure H-22	Reach Boulder 1		
	7-61	Measure H-28	Reaches Zigzag 1A and 1B		
Ch 8	8-156	8.3.2	Addition of effects on eulachon habitat in the lower Bull Run River, the Columbia River, effects on eulachon habitat from the HCP offsite measures, population effects and VSP parameters, and conclusions about the habitat effects of HCP measure implementation on eulachon.	Minor addition specific to eulachon	No

Chapter or Appendix	Document Page	Document Section	Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
	8-4	8.1.2	Clarification that the estimated production that would result from the HCP conservation measures does not include fish passage in Walker and Alder creeks	No	No
Ch 8			Under Effects of the Bull Run Measures on Lower Bull Run River Habitat, clarification of blocked stream miles in the Bull Run watershed in the Reference Condition and total number of miles provided by HCP measures under Habitat Effects of Conservation Measures for the four primary species:	No	No
	8-9	Table 8-2	Fall Chinook		
	8-43	Table 8-12	Spring Chinook		
	8-82	Table 8-26	Winter steelhead		
	8-120	Table 8-39	Coho		
		8.2.1	Clarification that the benefit level excludes the benefits of large wood additions for each primary covered species:	No	No
	8-39		Fall Chinook		
	8-78		Spring Chinook		
	8-116		Winter steelhead		
	8-153		Coho		
		Access	Correction of mileages blocked in the upper Bull Run River for three of the primary covered species:	No	Yes
	8-57		Spring Chinook		
	8-93		Winter steelhead		
	8-133		Coho		

Chapter or Appendix	Document Page	Document Section	Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
			Correction of Zigzag stream reaches affected by Zigzag measures:	No[c]	No
	8-72 and	Table 8-22	Spring Chinook		
	8-109	Table 8-35	Winter steelhead		
Ch 8		Summaries	Correction of mileages that will become accessible to winter steelhead and coho with the passage improvements in Alder and Cedar creeks:	No	No
	8-100		Winter steelhead		
	8-139		Coho		
	8-148		Corrections to percentages for diversity and abundance for Coho	No	Yes
	8-149	Table 8-50	Corrections to percentages for productivity and diversity for Coho	No	Yes
	8-150	Table 8-51	Corrections to adult abundance numbers for Coho	No	Yes
			Clarification of the flow requirements for exceedence of total dissolved gas (TDG) as well as the locations where elevated TDG levels have been observed in the Bull Run River for the four primary species:	No	No
	8-23		Fall Chinook		
	8-59		Spring Chinook		
	8-94 — 8-95		Winter steelhead		
	8-136		Coho		
			Clarification of additional stream miles available after the removal of Little Sandy Dam:	No	No
	8-22		Fall Chinook		

Chapter or Appendix	Document Page	Document Section	Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
	8-57 8-93 8-133		Spring Chinook Winter steelhead Coho		
Ch 8	8-156 – 8-157	Table 8-52	Addition of table showing historical distribution of rainbow trout in the Bull Run River (based on historical distribution of winter steelhead)	No	No
Ch 9	9-21	Total Dissolved Gas Research	Addition of exception to Oregon Administrative Rule 340-041-0031 on TDG and clarification of TDG locations within the Bull Run water system infrastructure	No	No
	9-28 and 9-29	Habitat Fund	Clarification of one of the functions of the Habitat Fund and explanation of how the Habitat Fund costs in Appendix I relate to the Habitat Fund discussions in chapters 9 and 11	No	No
Ch 10	10-1 – 10-3	10.2	Discussion of the City's monitoring of and preparation for climate change. Discussion includes a description of findings from the 2002 study on climate change in the Bull Run prepared by University of Washington staff.	No	No
Ch 11	All		All costs have been updated from 2006 dollars to 2008 dollars.	No	No
	11-10	Figure 11-1	Updated bar chart showing the scheduled funding increments over time	No	No
	11-11	11.3.1	Clarification on the lack of capped totals for Bull Run measures	No	No
App B	B-1		Clarification of the data sources for the river reach lengths	No	No

Chapter or Appendix	Document Page	Document Section	Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
App E			Correction to rounding error of percentage change for artificial confinement on reach Sandy 1 for all four primary covered species:	No	Yes
	E-5	Table E-6	Fall Chinook		
	E-7	Table E-8	Spring Chinook		
	E-12	Table E-13	Winter steelhead		
	E-17	Table E-18	Coho		
			Correction of Zigzag stream reaches affected by Zigzag measures for two species:	No[c]	No
	E-11	Table E-12	Spring Chinook		
	E-16	Table E-17	Winter steelhead		
App F	F-2	Table F-1	Correction of Zigzag treated reaches by treatment category	No	Yes
	F-4	Table F-2	Correction of attributes and measurable habitat objectives in Zigzag reaches affected by HCP measures and deletion of Zigzag 1B.		
	F-7	Table F-3	Correction to the Zigzag paired treated and control reaches		
App G	All		Temperature Management Plan as approved by Oregon Department of Environmental Quality in May 2008 (update from Public Review Draft)	No	No
App I	All		All costs have been updated from 2006 dollars to 2008 dollars.	No	No

[a]Changes population effects, VSP parameters, or conclusions about HCP effectiveness in Chapter 8.

[b]Change was included in Technical Errata memo to National Marine Fisheries Service, dated February 12, 2008.

[c]The habitat benefits tables in Chapter 8 (tables 8-22 and 8-35) and Appendix E (tables E-12 and E-17) were incorrect for Measure H-27 (Zigzag 1A Channel Design). Although the EDT model run used in the Public Review Draft of the HCP correctly incorporated the habitat benefits for reach Zigzag 1A (and excluded the benefits in Zigzag 1B), the tables in Chapter 8 and Appendix E incorrectly included benefits from an earlier analysis and had not been updated. These tables in Chapter 8 and Appendix E have been corrected.